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# Exploring efficacy: A comprehensive review of extended transsphenoidal approach in anterior skull base meningiomas

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## ABSTRACT

**Background:** Anterior skull base meningiomas can cause significant symptoms such as mass effect and neuropsychological decline, necessitating surgical resection. The endoscopic extended transnasal approach has emerged as a minimally invasive alternative to craniotomy, offering a means to address these tumors despite challenges due to the proximity of critical neurovascular structures and the high risk of complications such as cerebrospinal fluid (CSF) leaks. This systematic review and meta-analysis evaluate the safety and efficacy of extended transsphenoidal techniques in anterior skull base meningiomas.

**Methods:** This study followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and the Cochrane Handbook. A search was performed in Medline, Embase, Cochrane, and Ovid. Eligible studies included those (1) in English, (2) with patients having anterior skull base meningiomas, and (3) who underwent endoscopic surgical management. Endpoints included CSF leak, length of stay, complications, and mortality.

**Results:** The analysis included data from 23 studies involving 573 patients with a median age of 54.77 (range 39.5–67.3) years. Approximately 71% of participants were female. The mean length of stay was 7.50 days (95% confidence interval [CI]: 6.64–8.47). The overall complication rate was 35% (95% CI: 0.22–0.49), with minor complications also occurring in 6% of cases (95% CI: 0.02–0.10). Major complications were reported in 20% of cases (95% CI: 0.10–0.30). The CSF leak rate was 7% (95% CI: 0.04–0.10).

**Conclusion:** In the setting of complex anatomical challenges and inherent risks, the technique showed a moderate complication rate and length of hospital stay. This method demonstrated lower CSF leak and complication rates compared to previously published studies from the past decade.

**Keywords:** Cerebrospinal fluid leak, Endoscopic surgery, Meningiomas, Skull base, Transnasal

## INTRODUCTION

Meningiomas are common intracranial tumors and correspond to nearly one-third of all primary central nervous system lesions.[12] The majority, approximately 95%, are benign, and their incidence varies between the fourth and fifth decades, with a peak in the sixth decade with a female predilection.[1] It is well known that 6–13% of all meningiomas are skull-base tumors;[35] anterior skull base meningiomas represent 8.8% of all meningiomas.[1]

Anterior skull base meningiomas, according to their dimensions, may cause symptoms, namely mass effect, edema in adjacent neurovascular structures, loss of olfaction, loss of vision, and neuropsychological decline, and surgical resection is recommended as part of the treatment.[21] Over the past decades, surgical approaches have substantially progressed, and the endoscopic transnasal method has become a route as a minimally invasive technique to reach the anterior skull base[28] as an alternative to traditional open craniotomy. Although the surgical techniques have been enhanced, the anterior skull base meningioma resection remains challenging.[35]

The complexity of the skull-base meningiomas surgical removal derives from the intimate kinship between the meningiomas and the neurovascular brain structures.[8] likewise, anterior skull base lesion surgeries, due to the high risk of complications, such as postoperative and neurological deficits, also require high standard surgical experience, knowledge, and accurate technique.[35] Along with infection, vascular and rhinological,[4] cerebrospinal fluid (CSF) leak is particularly listed as one of the main complications associated with this approach.[23]

In the context of the complexity of anterior skull base meningiomas resection and the incidence of adverse events, notably the CSF leak episodes, it is relevant to quantitatively evaluate, as a minimally invasive alternative, endoscopic surgery technique complications occurrence; however, consistent data describing both intraoperative and postoperative outcome challenges of anterior skull base endoscopic approaches remains scarce.[28] From this perspective, this systematic meta-analysis review aims to evaluate the CSF leak outcomes in the endoscopic transsphenoidal surgery (ETS).

## MATERIALS AND METHODS

### Search strategy

A systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[29] Pubmed, Embase, Cochrane, and Ovid were the elected databases for searching for available literature. The following search strategies were utilized, stratified per database search language: Pubmed – (Tuberculum [Title/Abstract] OR Suprasellar [Title/Abstract] OR sellar [Title/Abstract] OR sella [Title/Abstract] OR sellae [Title/Abstract] OR cribriform [Title/Abstract] OR Planum [Title/abstract] OR Sphenoid* [Title/abstract] OR olfactory [Title/abstract] OR sphenoid bone [MeSH Terms] OR anterior skull base [Title/Abstract] OR skull base meningioma [Title/Abstract] OR “Cranial Fossa, Anterior” [Mesh]) AND (Meningioma* [Title/Abstract] OR meningioma [MeSH Terms] OR meningeal neoplasms [MeSH Terms] OR TSM [Title/abstract] OR OGM [Title/abstract] OR PSM [Title/abstract]), Embase – (Olfactory: ab,ti OR tuberculum: ab,ti OR suprasellar: ab,ti OR sellar: ab,ti OR sella: ab,ti OR Sellae: ab,ti OR planum: ab,ti OR cribriform: ab,ti OR sphenoid*:ab,ti OR “sphenoid”/exp OR “anterior skull base”:ab,ti) AND (meningioma*:ab,ti OR “meningioma”/exp OR meningioma*ab,ti OR TSM: ab,ti OR OGM: ab,ti OR PSM: ab,ti), Cochrane – (Tuberculum OR Suprasellar OR sellar OR sella OR sellae OR cribriform OR Planum OR Sphenoid* OR olfactory OR sphenoid bone OR anterior skull base OR “Cranial Fossa, Anterior”) AND (Meningioma* OR meningioma OR meningeal neoplasms OR TSM OR OGM OR PSM), and Ovid – (Tuberculum OR Suprasellar OR sellar OR sella OR sellae OR cribriform OR Planum OR Sphenoid* OR olfactory OR sphenoid bone OR anterior skull base OR “Cranial Fossa, Anterior”) AND (Meningioma* OR meningioma OR meningeal neoplasms OR TSM OR OGM OR PSM). The resulting abstracts were pooled, duplicated were excluded and title and abstract screening ensued by two authors (CA and LPM). The studies included in this review were selected from a comprehensive search spanning from 1980 to 2024. Only studies that focused on the EEA in anterior skull base meningiomas and presented at least one analyzable outcomes were included in the study. The selection process was conducted using Rayyan software[27], which facilitated the identification of eligible studies. Following this, a full-text analysis was performed to ensure each study met the inclusion criteria, and relevant data were systematically extracted to evaluate the outcomes of interest.

### Eligibility criteria

Key inclusion criteria included: (1) full-text available and published in the English language, (2) any study design characteristic, either retrospective or prospective, (3) reporting outcomes of interest, (4) on anterior skull base meningiomas about the tuberculum sellae, sphenoid bone, olfactory groove, and cribriform plate, confirmed through imaging or biopsy, and (5) that underwent surgical management in any phase of the treatment though an extended endoscopic transsphenoidal approach. Studies were excluded if they were published in a foreign language or full text was unavailable, on tumors other than meningiomas, undergoing other types of treatment than the surgical possibilities stated in the inclusion criteria, or reporting data outside of the outcomes of interest or in an aggregate fashion.

### Outcomes definitions

Outcomes of interest included baseline demographic characteristics of patients, such as age and gender, the histologic examination and subtype of tumors, along with meningioma World Health Organization grade, mean follow-up, preoperative magnetic resonance imaging (MRI) findings, such as preoperative tumor volume, volume of tumor edema, planum, and tuberculum involvement; postoperative MRI findings, such as change in fluid-attenuated inversion recovery volume, porencephalic change in volume, mean postoperative tumor volume, and total change in volume (tumor + edema), extent of resection (Gross total, near total, and subtotal resections), and Simpson's Scale of Resection. Additional outcomes of interest were assessed, such as data on preoperative symptomatology and initial tumor findings, such as Karnofsky Performance Scale on the immediate postoperative functional outcome, meningioma diameter size, initial symptoms, presence of visual symptoms, preoperative and postoperative visual impairment scores, preoperative and postoperative Glasgow outcome scale scores, and initial interval from onset diagnosis to surgery. Other outcomes of interest, such as data on visual field and acuity outcomes, major and minor complications, and mortality, were considered. Major complications were considered when presented as permanent and requiring further invasive interventions, while minor complications were considered transient and did not need further interventions. Tumor-related mortality was defined as any mortality related to or caused by tumor presentation, procedure, subsequent treatment, and postoperative course and follow-up.

### Risk of bias assessment

The included studies' bias was assessed using the Risk of Bias In Non-randomized Studies–of Interventions (ROBINS-I) tool.[33] According to the criteria described in the tool's guidelines, each of the five domains of ROBINS-I was assigned a low, moderate, serious, or critical classification, with an overall score assigned to each study accordingly.

### Statistical analysis

This systematic review and meta-analysis were performed according to the Cochrane Collaboration and the PRISMA statement guidelines.[29] Relative risk with 95% confidence intervals (CIs) were used to compare outcome treatment effects. $I^2$ statistics were used to assess for heterogeneity; *P*-values inferior to 0.05 and $I^2 < 35\%$ were considered significant. Given the retrospective and nonrandomized nature of included studies, a random effects analysis of outcomes were preferred. Statistical analysis was performed using the software R (version 4.2.3, R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Study selection

On searching PubMed, Embase, Cochrane, and Ovid, we identified 1060 studies. After deduplication, 724 non-duplicated studies were screened, with 668 excluded due to their lack of relevance based on title and abstract screening. The remaining 56 articles underwent a full-text review to assess their eligibility. Ultimately, 23 studies[2,3,5,6,7,9-11,13-16,17,18,19,20,22,24,25,26,30-32,36] met the inclusion criteria and were included in the final analysis. The study selection process is graphically represented in Figure 1.

### Baseline characteristics

The data for this meta-analysis were derived from 23 studies evaluating the transsphenoidal approach for treating meningiomas in the anterior fossa, encompassing a total of 573 patients. Within this cohort, the median age was 54.77 (range 39.5–67.3) years. Female patients constituted the majority, approximately 71%, of the study population. Included studies reported tumors invading the Tuberculum Sellae, Olfactory Groove, Planum Sphenoidale, Olfactory Sulcus, and Orbital Roof. More detailed information is available in Table 1.

In the studies analyzed, a total of 184 complications were reported among 573 patients, categorized as either major or minor. Specifically, there were 123 major complications and 45 minor complications. The most common complications included CSF leaks, occurring in 44 cases (20.05%), meningitis in 19 cases (9.09%), and anosmia in 10 cases (4.7%).

### Quality assessment

The assessments of methodological risk of bias are visually displayed in Figure 2, presenting a comprehensive overview of the included studies. It is important to note that the retrospective nature of these studies places them in the moderate risk category according to the first domain of risk assessment.

To better elucidate the influence of bias across the included studies, Figure 3 presents a detailed breakdown of the average risk of bias, organized by specific criteria and overall risk assessment. This visualization offers crucial insights into how bias may affect the study outcomes.

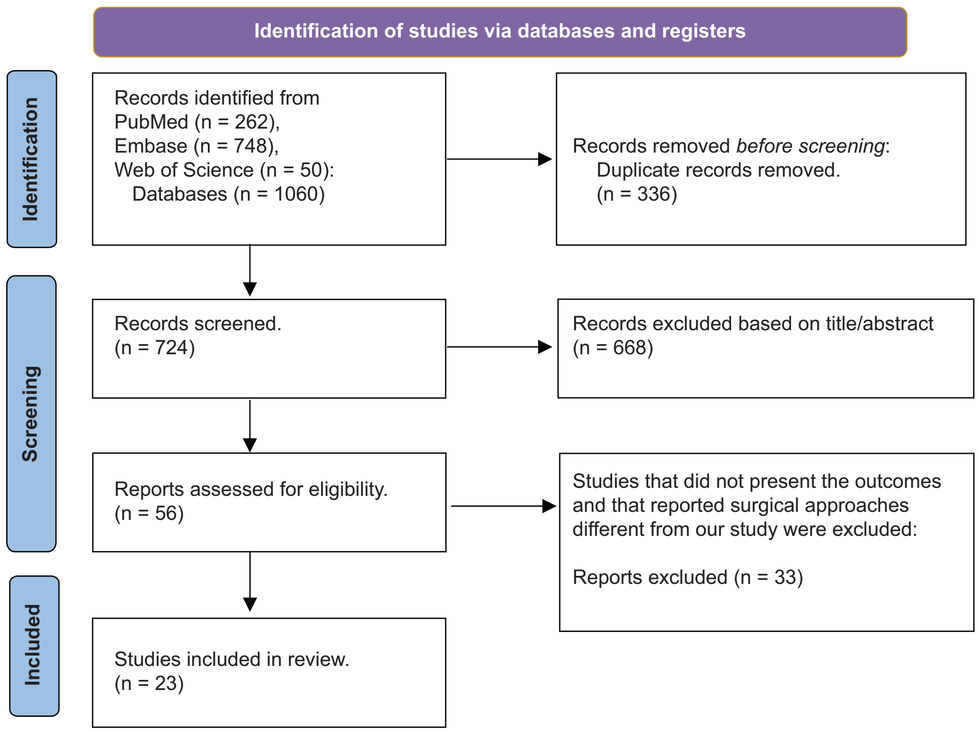


**Figure 1:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study screening and selection.

## Pooled analysis of studies

### *CSF leak*

The CSF leak was assessed in all 23 studies for the entire population of 573 patients. The analysis revealed an estimated 7% rate of CSF Leak (Proportion = 0.07; 95% CI [0.04–0.10]; $I^2$ = 47% [Figure 4]).

### *Lumbar drain (LD)*

In our analysis, the LD was performed on 15% of patients (Proportion = 0.15; 95% CI [0.01–0.29]; $I^2$ = 89% [Figure 5]).

### *Complications*

Complications were reported in 23 studies, encompassing a total of 573 patients. Detailed findings from individual studies are presented in Table 2. The estimated rate of overall complications was 35% (Proportion = 0.35; 95% CI [0.22–0.49]; $I^2$ = 95% – [Figure 6]). Major complications occurred in 20% of this population (Proportion = 0.20; 95% CI [0.10–0.30]; $I^2$ = 89% [Figure 7]), while minor complications were noted in 6% (Proportion = 0.06; 95% CI [0.02–0.10]; $I^2$ = 66% – [Figure 8]).

### *Length of stay*

Regarding length of stay, five studies with a total population of 156 were analyzed. In this pooled analysis, the mean length of stay was 7.50 days (Mean = 7.50 [6.64–8.47]; $I^2$ = 38% [Figure 9]).

### *Mortality*

The analysis of the mortality rate directly related to the procedure in patients treated through a transsphenoidal approach for meningioma was assessed by 21 studies, with a total of 497 patients. In our pooled analysis, a total of 3 deaths were reported – the estimated mortality rate was 1% (Proportion = 0.01; 95% CI [0.00–0.02]; $I^2$ = 0% [Figure 10]).

## DISCUSSION

This systematic review and meta-analysis, encompassing 23 studies with a cumulative patient population of 573, comprehensively evaluates the EEA in meningiomas of the anterior fossa. The primary outcomes from the analysis performed within this population were as follows: (1) the CSF leak was presented in 7% of the patients; (2) LD was performed on 15% of patients; (3) major and minor postoperative complication rate, was 20% and 6%, respectively; (4) mean length of hospital stay was 7.50 days; and (5) mortality was reported in 1% of patients.

Meningiomas are the most common type of primary brain tumor, and those located within the anterior fossa present unique clinical considerations and challenges. The anterior fossa is a critical region of the skull base, housing vital structures such as the olfactory bulbs, optic nerves, and

**Table 1:** Baseline characteristics.

| Study (First author last name Year) | Number of patients | Number of male patients | Number of Female patients | Age Mean±SD (Range) y/o | Meningioma types | Tumor size |
|---|---|---|---|---|---|---|
| Cook *et al*., 2004 | 3 | 0 | 3 | 40.3 (32–55) | Tuberculum Sellae | 2×2 cm |
| Fatemi *et al*., 2009 | 14 | 4 | 10 | 51±15 | Tuberculum Sellae | 2.8 (2.0–5.5) cm |
| Bowers *et al*., 2011 | 4 | NR/IG | NR/IG | 54 (23–77) | Tuberculum Sellae | 1.3–5.4 cm |
| Bohman *et al*., 2012 | 5 | 2 | 3 | 53.2 | Tuberculum Sellae | NR |
| Chowdhury *et al*., 2012 | 6 | 2 | 4 | 39.5 (29–52) | Tuberculum Sellae | NR |
| Ogawa and Tominaga 2012 | 19 | 5 | 14 | 58.9 (43–79) | Tuberculum Sellae | 2.16 cm |
| Gadgil *et al*., 2013 | 5 | 2 | 3 | 51 (31–66) | Tuberculum Sellae | 6.3 cm3 (2.3–11.9) |
| Khan, 2014 | 23 | 4 | 18 | 59.3±14 (33–88) | Olfactory Groove and Tuberculum Sellae | OGM: 1.3–5.2 $cm^3$ TS: 1.0–3.3 $cm^3$ |
| Koutourousiou *et al*., 2014 | 75 | 14 | 61 | 57.3 (36–88) | Tuberculum Sellae; Planum Sphenoidale+ Tuberculum Sellae; and Planum Sphenoidale | 2.3 cm (0.7–5.2) |
| Banu *et al*., 2016 | 6 | 0 | 6 | 67.3 (48–77) | Olfactory Groove | 30.5 (3.2–80.7) $cm^3$ |
| Ceylan *et al*., 2015 | 23 | 6 | 17 | 52.04 (32–78) | Tuberculum Sellae | 2.5 (1.2–4.5) cm |
| Hayhurst *et al*., 2016 | 19 | 5 | 21 | 50 (28–76). | Olfactory Groove; Planum Sphenoidale; Tuberculum Sellae | 2.5 (0.8–5.5) cm |
| Bander, 2018 | 17 | NR/IG | NR/IG | 54.97±13.5 | Tuberculum Sellae; Planum Sphenoidale | 5.58±3.42 cm |
| Hayashi *et al*., 2017 | 22 | 7 | 15 | 58.2 (32–87) | Tuberculum Sellae | 2.4 (1.5–3.4) cm |
| Linsler *et al*., 2017 | 6 | NR/IG | NR/IG | 62.4±11.7 | Tuberculum Sellae | 2.1±0.8 $cm^3$ |
| Song *et al*., 2018 | 44 | NR/IG | NR/IG | 52.7 (26–76) | Tuberculum Sellae | 5.8±3.4 $cm^3$ |
| Bernat *et al*., 2018 | 26 | NR/IG | NR/IG | 59±14 (55–63) | Olfactory Groove; Tuberculum Sellae | NR |
| Ottenhausen *et al*., 2018 | 32 | 11 | 21 | 59.8 (27–93) | Olfactory Groove; Planum Sphenoidale+ Tuberculum Sellae | 14.0 cm3±15.4 (2.2–66.1) |
| Yu *et al*., 2021 | 40 | 3 | 37 | 58.9 (42–73) | Tuberculum Sellae | 2.4 (1.6–3.8) cm |
| Qian *et al*., 2022 | 34 | 12 | 22 | 51.0±11.2 | Tuberculum Sellae | 10.7 cm3 |
| Galvez, 2023 | 79 | NR | NR | NR | Tuberculum Sellae; Planum Sphenoidale; Olfactory Sulcus; and Orbital Roof | 66.6 cm3 |
| Feng *et al*., 2023 | 45 | 39 | 6 | 53.4 (19.1) | Tuberculum Sellae | 10.97 $cm^3$ |
| Truong *et al*., 2023 | 26 | 6 | 20 | 56 (30–72) | Tuberculum Sellae; Planum Sphenoidale; and Olfactory Groove | 2.5 (1.1–3.9) $cm^3$ |

NR: Not reported, NR/IG: Not reported for an interest group, OGM: Olfactory groove meningioma, TS: Tuberculum sellae meningioma; due to lack of information, we were not able to standardize the tumor size metrics, SD: Standard deviation

frontal lobes of the brain. Despite advancements in surgical techniques and adjuvant therapies, the management of anterior fossa meningiomas remains complex, and optimal outcomes require careful consideration of individual patient factors and tumor characteristics. The EEA for anterior skull base meningiomas was developed with the expectation of achieving more complete resection (Simpson grade I) using a less invasive approach.

One of the notable challenges remains the potential for complications, including CSF leaks. They occur when there is an abnormal communication between the subarachnoid spaces. In the case of anterior fossa meningiomas, the tumor itself can create a breach in the dura mater, allowing CSF to escape into the nasal cavity or sinuses, possibly contributing to CSF leak. The previous studies have shown that the proportion of patients experiencing a CSF leak decreased progressively over time, from 22% (95% CI: 6–43%) in studies published between 2004 and 2010, to 16% (95% CI: 11–23%) between 2011 and 2015, and further to 4% (95% CI: 1–9%) between 2016 and 2020. Our study, covering publications

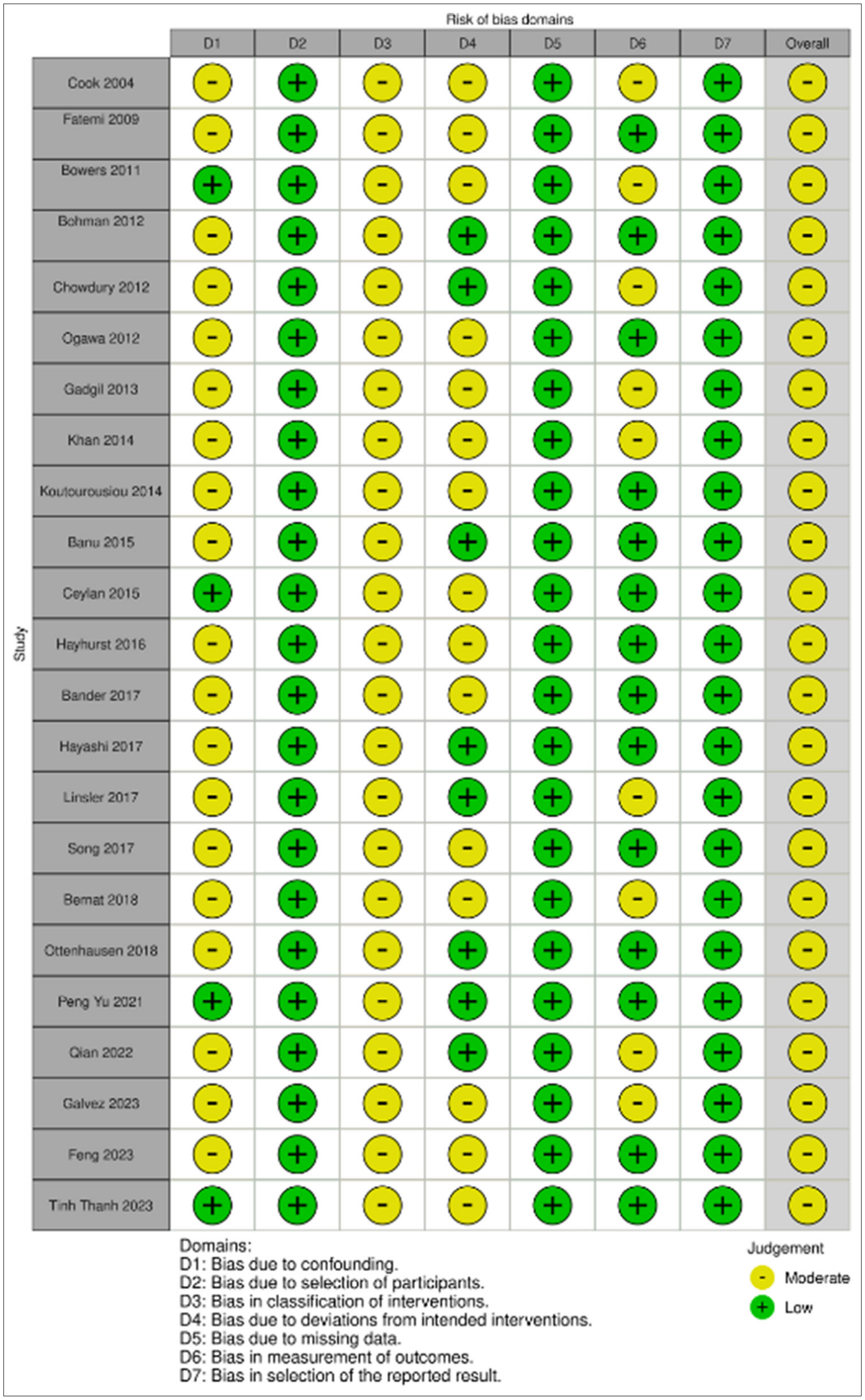


**Figure 2:** Risk of bias in non-randomized studies–of interventions tool for risk of bias assessment.

from 2004 to 2023, demonstrates a notable decline in the occurrence of CSF leaks over nearly two decades, with a prevalence of only 8% among patients (95% CI: 4–10%). However, it's worth noting that our findings slightly exceed

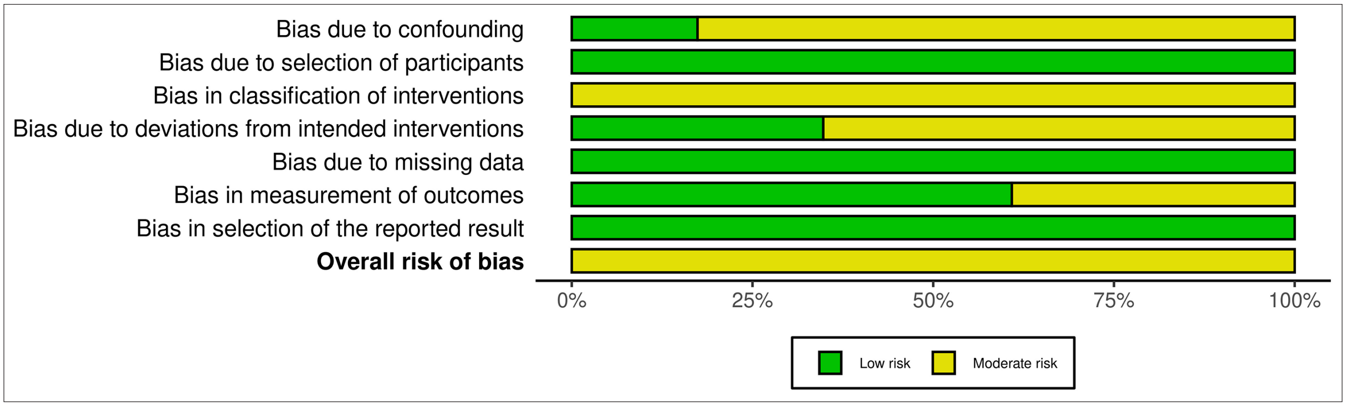


**Figure 3:** Average risk of bias contributions.

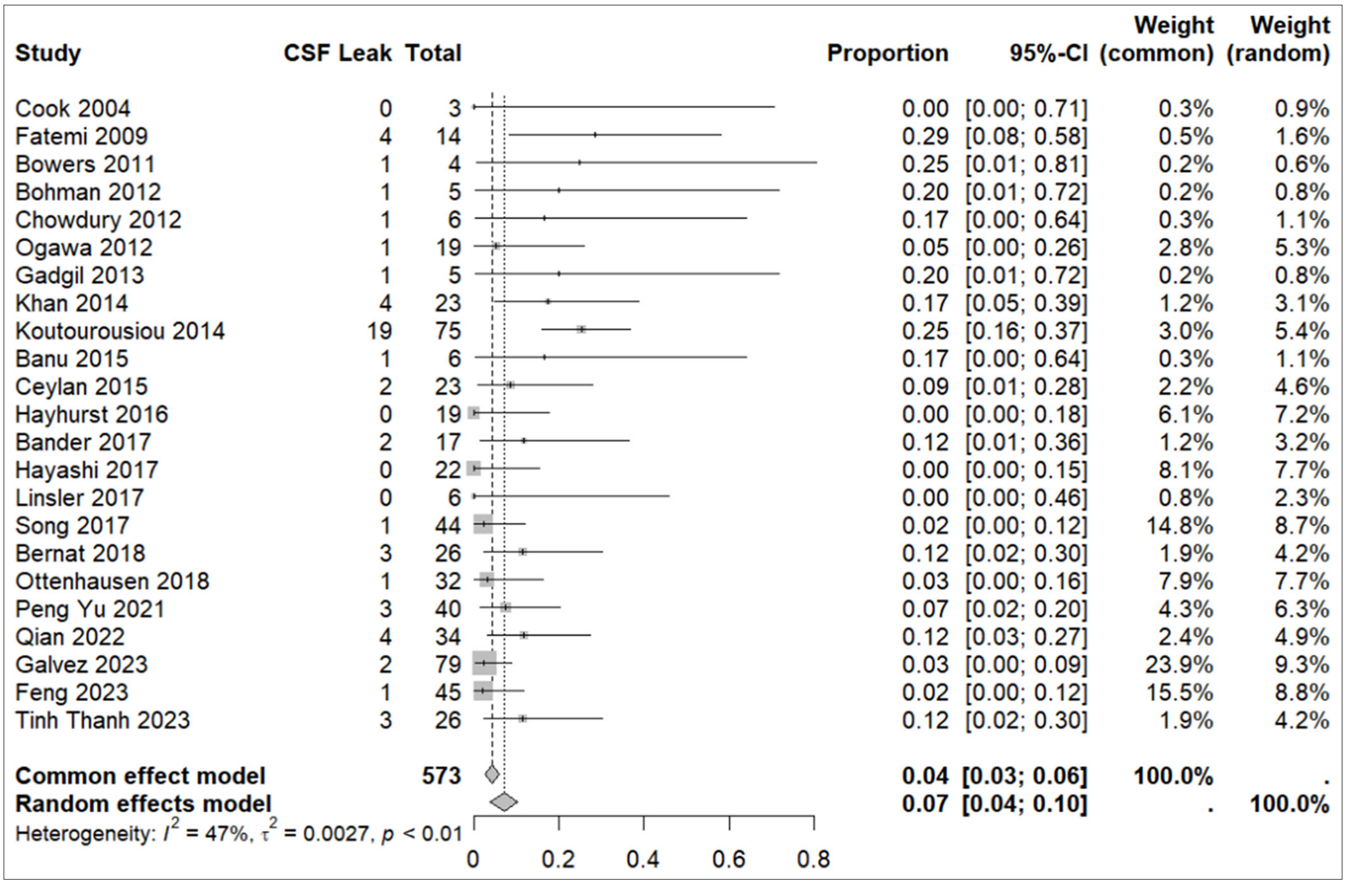


**Figure 4:** Forest plot of cerebrospinal fluid (CSF) leak. (CI: Confidence interval)

those reported in the last published meta-analysis from 2016 to 2020. We hypothesize that this variation may stem from differences in experience among endoscopic surgeons, with practitioners at various stages of their learning curve. In addition, we attempted to pool all anterior fossa meningiomas, not generating subsets of variables pertaining specifically to tuberculum meningiomas and olfactory groove meningiomas, which could lead to lower overall pooled rates of CSF leak, with olfactory groove meningiomas CSF leak rates ranging from 20% to 30%.[34] Nevertheless, it is noteworthy that the proportion of CSF leaks has consistently decreased in recent years. That may be credited to advancements and refinements in closure techniques, such as the vascularized pedicled Hadad-Bassagasteguy flap and the gasket seal closure technique.[35]

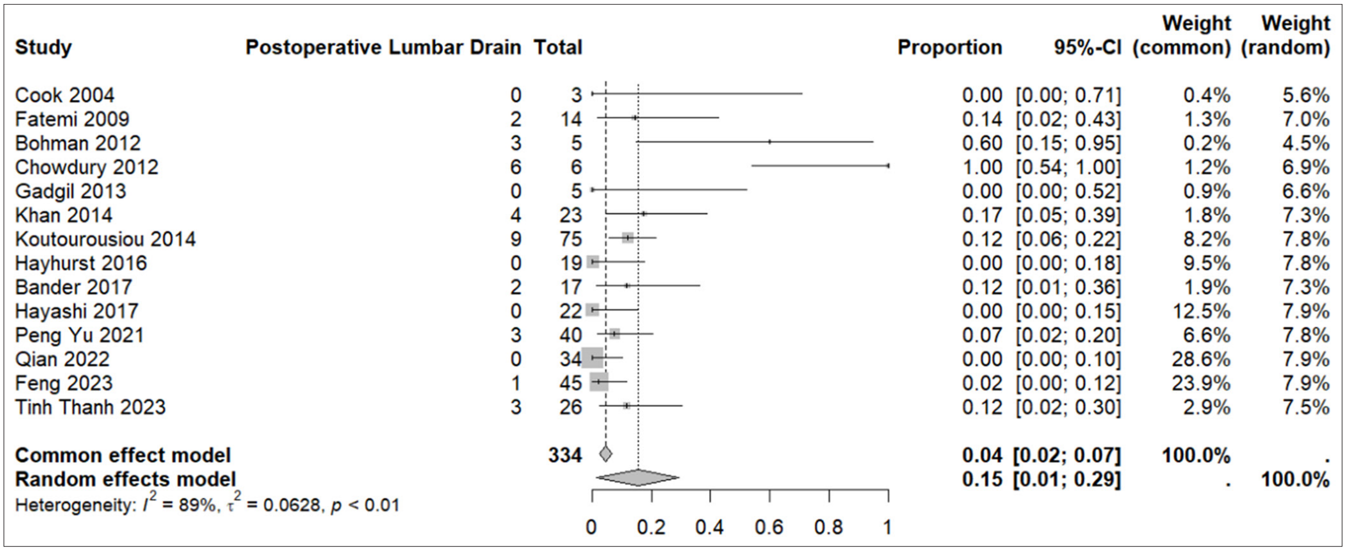


**Figure 5:** Forest plot of a postoperative lumbar drain. (CI: Confidence interval)

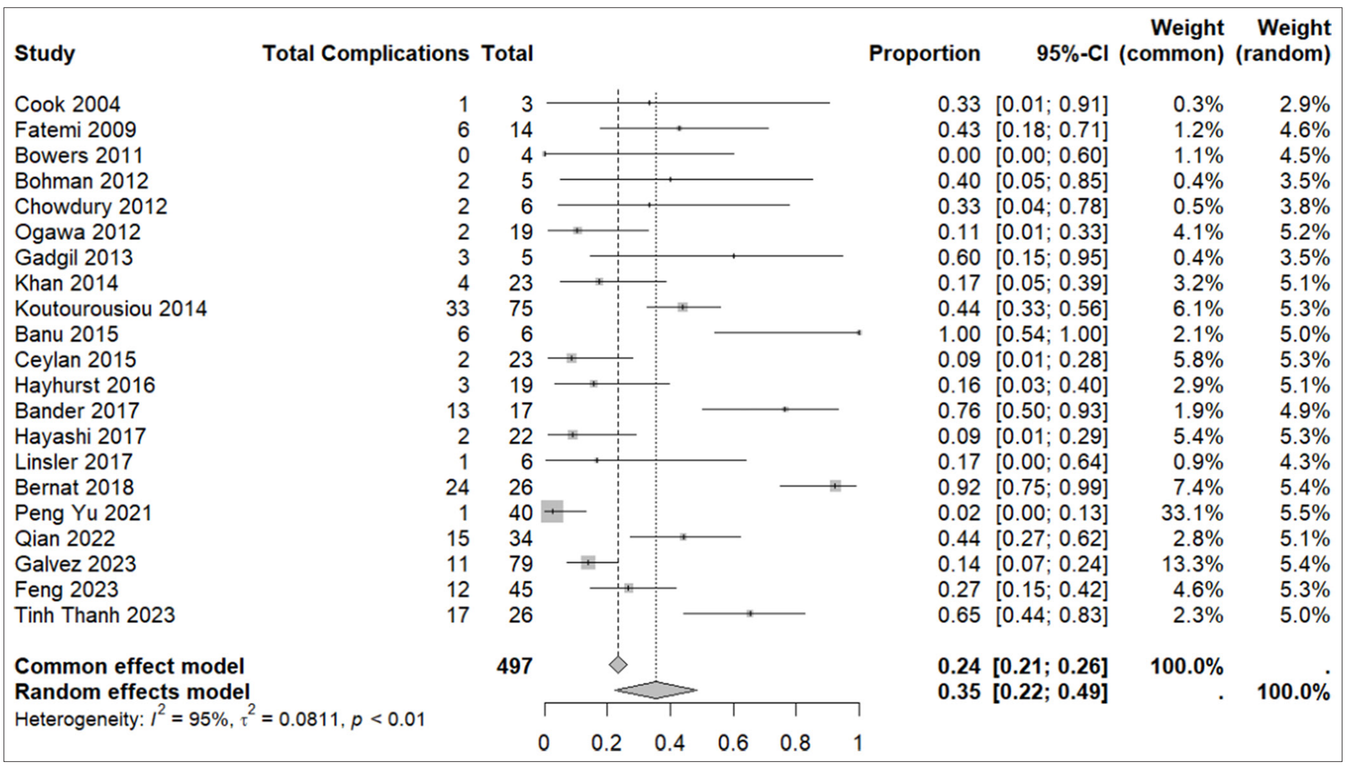


**Figure 6:** Forest plot of overall complications. (CI: Confidence interval)

It is recognized that the placement of a LD at the beginning of an operation, followed by drainage post-surgery, has been recommended. The primary advantage is to aid in the healing of the dural defect by reducing intracranial pressure and offering an alternative route for CSF drainage from the subarachnoid space. However, its effectiveness is not universally acknowledged, especially concerning high-flow CSF leaks, as well as the possibility of complications such as spinal headaches, infections, tension pneumocephalus, and uncal herniation. In our analysis, LD placement was observed in 15% of patients (95% CI: 1–29%), highlighting potential concerns in clinical practice regarding the risk-to-benefit ratio, especially given the uncertain utility of this approach.

Regarding the adverse events, we report a 20% incidence of major complications and a 6% of minor complications.

**Table 2:** Complications.

| Study | Patients | Complications | Total reported complications |
|---|---|---|---|
| Cook *et al.*, 2004 | 3 | Adrenal insufficiency 1. | 1 |
| Fatemi *et al.*, 2009 | 14 | Hypopituitarism 1;<br>CSF Leak 4;<br>Vision Worsening 1. | 6 |
| Bowers *et al.*, 2011 | 4 | No Complications. | 0 |
| Bohman *et al.*, 2012 | 5 | Hyponatremia 2. | 2 |
| Chowdhury *et al.*, 2012 | 6 | Hyponatremia 2. | 2 |
| Ogawa and Tominaga 2012 | 19 | Moyamoya Syndrome 1;<br>CSF Leak 1. | 2 |
| Gadgil *et al.*, 2013 | 5 | CSF Leak 1;<br>Meningitis 1;<br>Transient Diabetes Insipidus 1. | 3 |
| Khan 2014 | 23 | Toxic Shock Syndrome 1;<br>Transient Diabetes Insipidus 3. | 4 |
| Koutourousiou *et al.*, 2014 | 75 | CSF Leak 19;<br>Meningitis 4;<br>SIADH 4;<br>Hydrocephalus 2;<br>Permanent Diabetes Insipidus 1;<br>Seizures 1;<br>Pulmonary Embolism 1;<br>Respiratory Failure 1. | 33 |
| Banu *et al.*, 2016 | 6 | Anosmia 6;<br>Behavioral Changes 1;<br>Infection 2;<br>Opercular Infarction 1;<br>DVT/Pulmonary Edema 1;<br>Hematoma with Mass Effect 2;<br>CSF Leak 1. | 6 |
| Ceylan *et al.*, 2015 | 23 | Permanent Diabetes Insipidus 1;<br>Transient Diabetes Insipidus 1. | 2 |
| Hayhurst *et al.*, 2016 | 19 | Frontal infarct 1;<br>Meningitis 1 ;<br>CSF Leak 1. | 3 |
| Bander, 2018 | 17 | CSF Leak 2;<br>Headache 8;<br>Anosmia/Aguesia 2;<br>Weakness 1; | 13 |
| Hayashi *et al.*, 2017 | 22 | Transient Diabetes Insipidus 1;<br>Transient CN Damage 1. | 2 |
| Linsler *et al.*, 2017 | 6 | Hyposmia 1. | 1 |
| Song *et al.*, 2018 | 44 | Meningitis 7;<br>CSF Leak 1;<br>Anosmia or Hyposmia 13;<br>Transient Endocrinologic Complications 3. | 24 |
| Bernat *et al.*, 2018 | 26 | Non-specific Complications 5;<br>Endocrine Abnormalities 3. | 8 |
| Ottenhausen *et al.*, 2018 | 32 | Hematoma 1;<br>CSF Leak 1;<br>Combined Hematoma 1;<br>Mucocele 1. | 4 |
| Yu *et al.*, 2021 | 40 | Cerebral Infarction 1. | 1 |

(*Contd...*)

**Table 2:** (*Continued*).

| Study | Patients | Complications | Total reported complications |
|---|---|---|---|
| Qian *et al.*, 2022 | 34 | CSF Leak 4;<br>Meningitis 3;<br>Hypopituitarism 5;<br>Permanent Diabetes Insipidus 2;<br>Hemorrhage 1. | 15 |
| Galvez, 2023 | 79 | Hydrocephalus 2;<br>CSF Leak 2;<br>Haematoma 1;<br>Diabetes Insipidus 2;<br>Infarction 2;<br>CN Damage 2. | 11 |
| Feng *et al.*, 2023 | 45 | CSF Leak 1;<br>CN Damage 4;<br>Transient Diabetes insipidus 2;<br>Transient Hypercortisolism 5. | 12 |
| Truong *et al.*, 2023 | 26 | CSF Leak 3;<br>Meningitis 3;<br>Sinusitis 4;<br>SIADH 2;<br>Visual Deterioration 1;<br>Transient Diabetes Insipidus 2;<br>Anosmia 2. | 17 |

CSF: Cerebrospinal fluid, SIADH: Syndrome of inappropriate antidiuretic hormone secretion, DVT: Deep vein thrombosis, CN: Cranial nerve

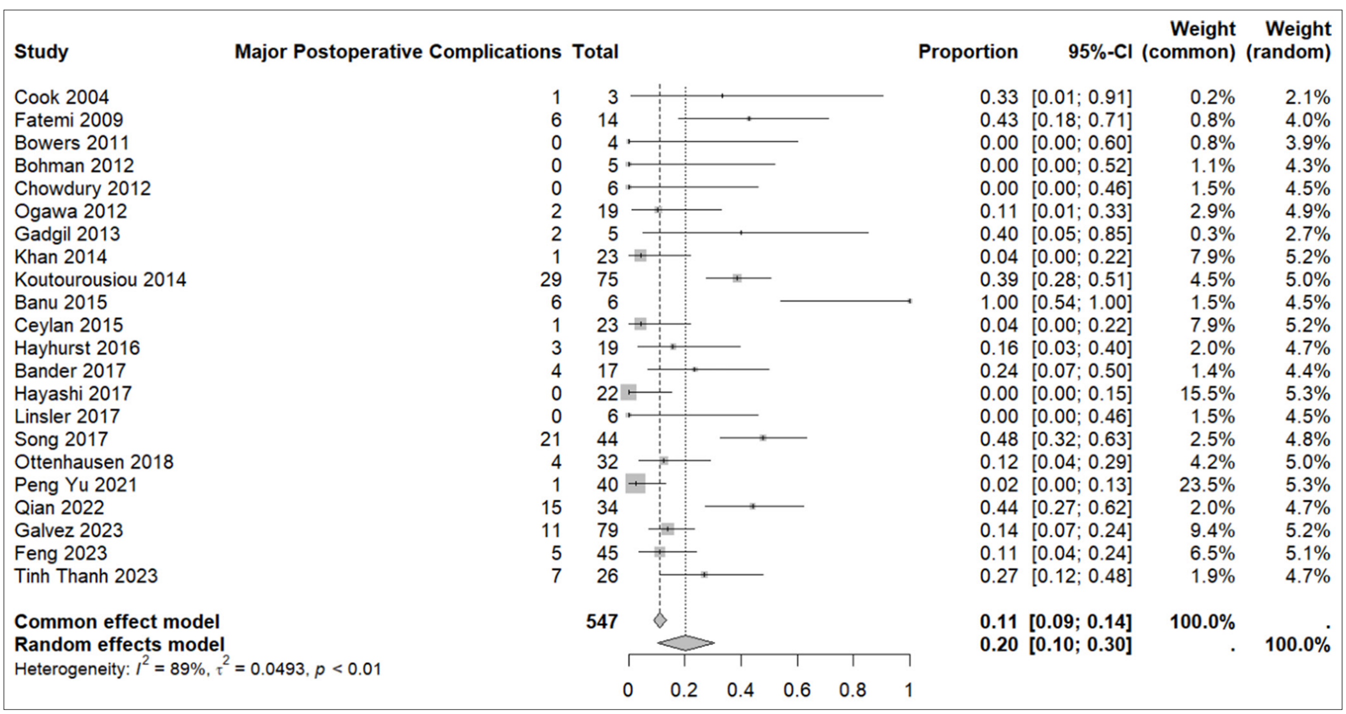


**Figure 7:** Forest plot of major postoperative complications. (CI: Confidence interval)

Complications are categorized based on the anatomical structures involved during operative stages, primarily as rhinological, CSF leaks, infection, and vascular complications. Endocrinological complications are typically

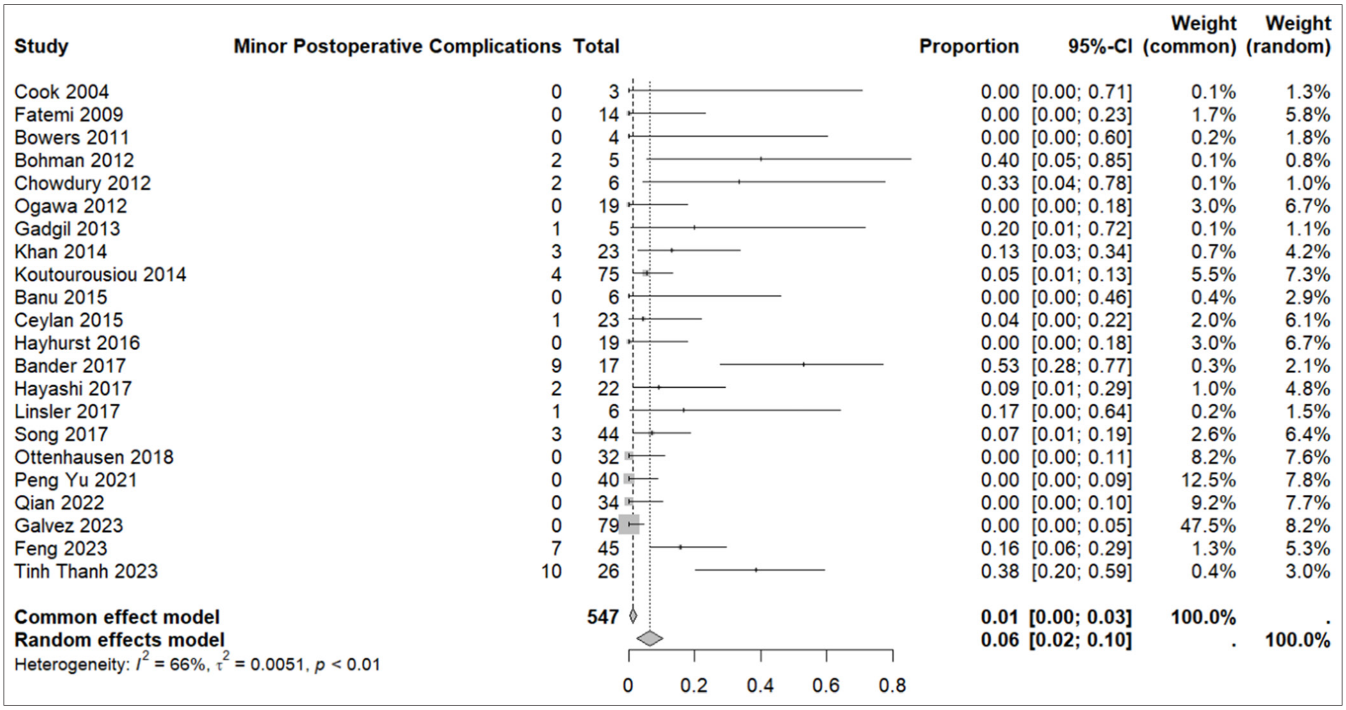


**Figure 8:** Forest plot of minor postoperative complications. (CI: Confidence interval)

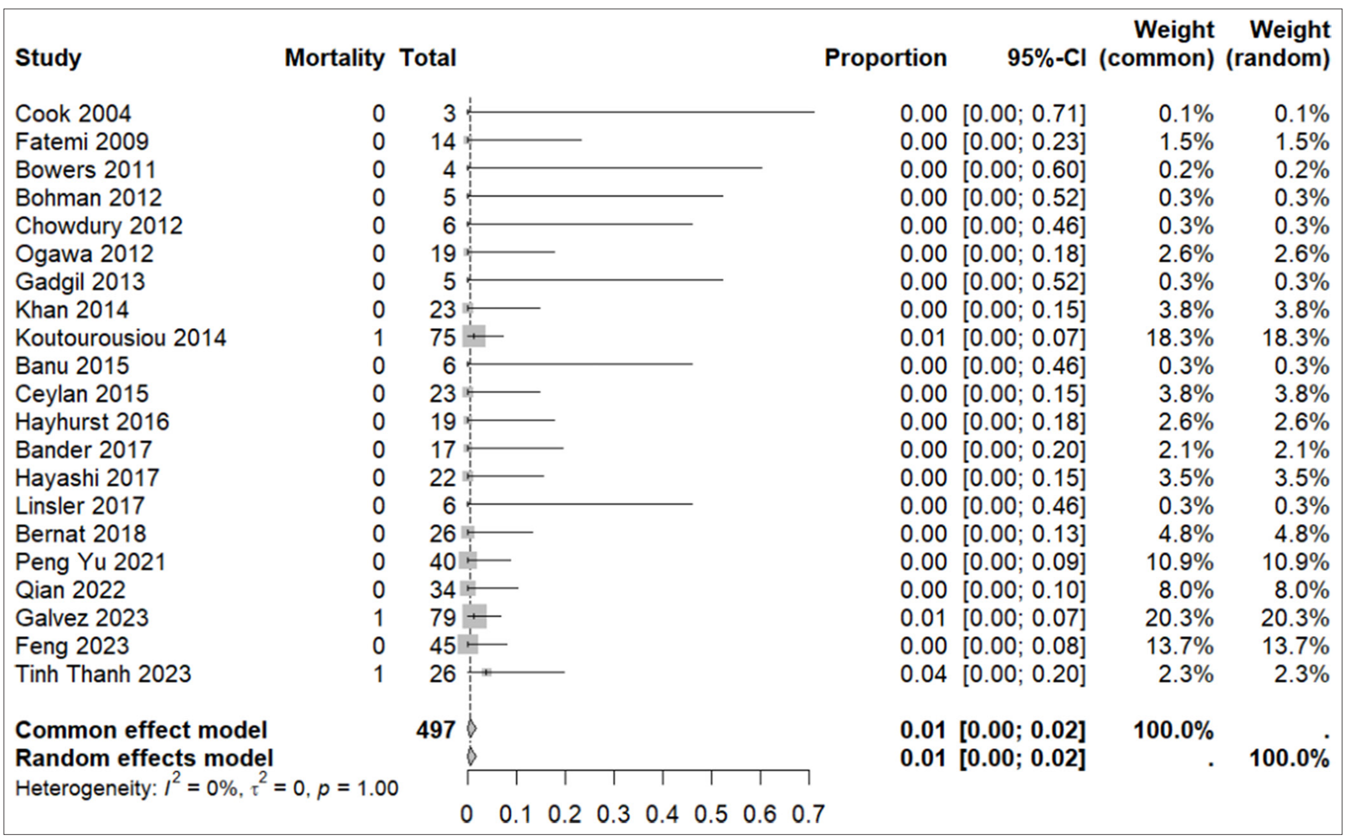


**Figure 9:** Forest plot of length of stay. (CI: Confidence interval)

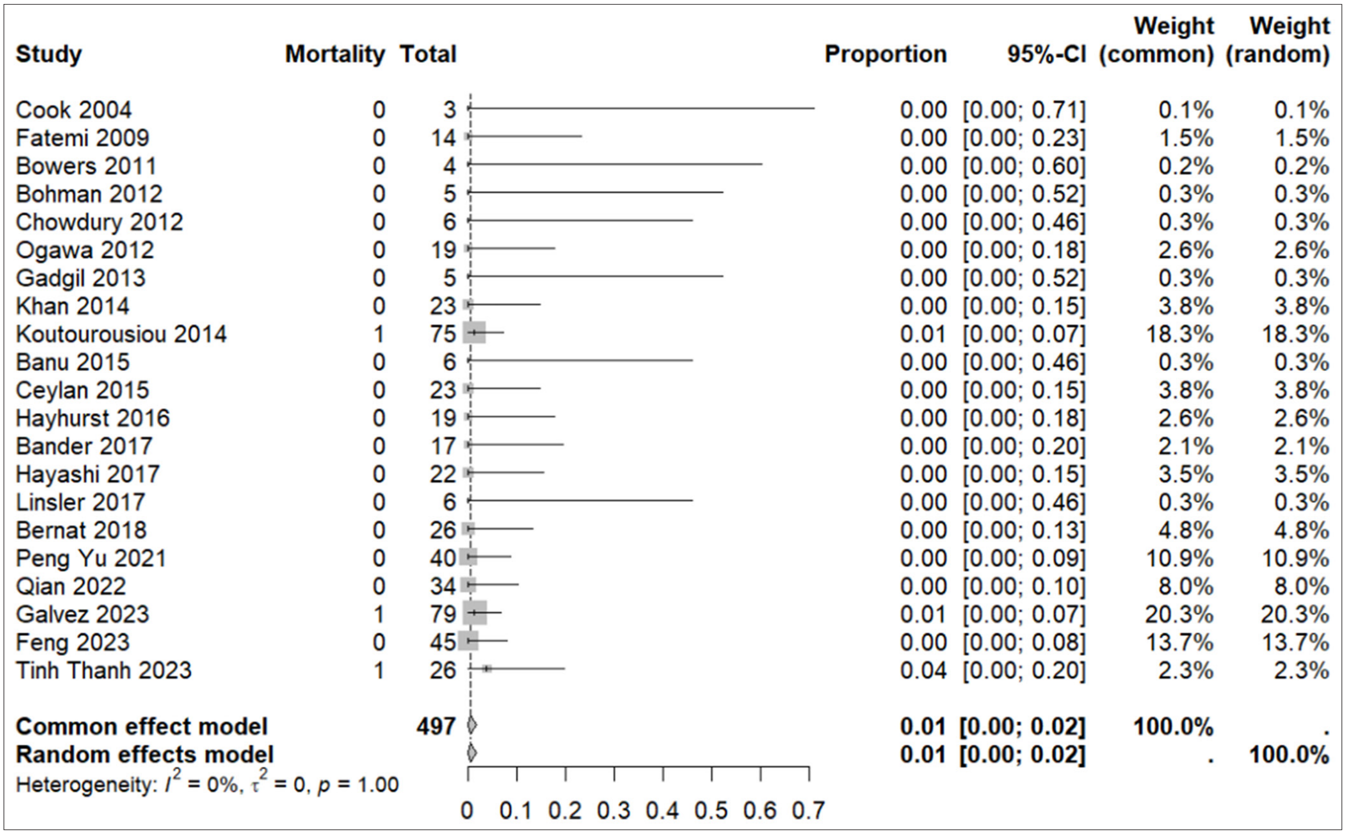


**Figure 10:** Forest plot of mortality.

further subdivided into anterior and posterior pituitary dysfunctions. The incidence of complications is notably higher in studies with larger sample sizes and a greater proportion of patients encountering CSF leaks. Nevertheless, the mortality rate remained consistent at 1% among patients (95% CI: 0–1%), indicating stability over time.

### Limitations

Our meta-analysis data have limitations inherent to this research design. Specifically, surgery studies have an intrinsic bias due to the surgeons' experience and management of tumor resection. The small number of published studies with potentially highly selected patient groups introduces the possibility of selection bias and publication bias, which cannot be entirely ruled out, mainly considering the study design most frequently presented, non-randomized. Finally, conceptual disagreements about anatomical delimitations may impair the objective differentiation of tuberculum sellae and planum sphenoidale meningiomas, especially when assessing large masses.

## CONCLUSION

This systematic review and meta-analysis, which analyzed data from 23 studies involving 573 patients, assessed the EEA for anterior fossa meningiomas. Key findings include a 7% rate of CSF leaks, 15% of patients undergoing LD placement, major and minor complication rates of 20% and 6%, respectively, a mean hospital stay of 7.5 days, and a 1% mortality rate. The research is significant because it evaluates a minimally invasive surgical option for managing anterior fossa meningiomas, which are located near critical structures such as the olfactory bulbs and optic nerves. This helps in improving surgical techniques and patient outcomes. Future research should aim at conducting prospective, randomized controlled trials to reduce biases and focus on long-term outcomes and quality of life. In addition, exploring advanced surgical techniques and conducting comparative studies with traditional approaches would further enhance the understanding and management of anterior fossa meningiomas.

### Authors' contributions

LBP and LPM: Contributed to study conceptualization, methodology, data curation, and project administration; BVN, FH, MYF, and CA : Responsible for data curation and scientific investigation; PVZR, IVB, LBO, FCG, FVR and GLC :Responsible for writing the original draft and visualization; RB and JAL : Responsible for reviewing the manuscript and supervising the project; All authors read and approved the final version of this manuscript.

### Ethical approval

The Institutional Review Board approval is not required.

### Declaration of patient consent

Patient's consent was not required as there are no patients in this study.


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Nil.


### Conflicts of interest

There are no conflicts of interest.

### Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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