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Efficacy of Dural Reconstruction Techniques for CSF Leak Prevention after Endoscopic Endonasal Approaches: A Systematic Review and Meta-analysis of Comparative Effectiveness

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ADMINISTRATIVE INFORMATION

Support - No support.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 23 September 2026 and was last updated on 23 September 2026.

INTRODUCTION

Review question / Objective To systematically evaluate and compare the effectiveness of dural and skull base reconstruction techniques for preventing postoperative cerebrospinal fluid (CSF) leakage in patients undergoing endoscopic endonasal approaches (EEA) or extended endoscopic endonasal approaches (EEEA), and to examine how reconstruction strategies vary according to intraoperative CSF leak severity and anatomical defect characteristics.

Condition being studied Postoperative cerebrospinal fluid (CSF) leakage is an important complication of endoscopic endonasal approaches (EEA) and extended endoscopic endonasal approaches (EEEA) for sellar, parasellar, and skull base lesions. Dural opening and disruption of the arachnoid or CSF spaces during surgery may create skull base defects with varying degrees of intraoperative CSF leakage. Persistent postoperative CSF leakage may result in clinically significant morbidity, including intracranial hypotension and central nervous system infection. Various reconstruction strategies, including autologous or synthetic grafts, vascularized nasoseptal flaps, dural suturing, rigid buttress techniques, and tissue sealants, have been developed to restore the skull base barrier and prevent postoperative CSF leakage. However, reconstruction practices vary considerably according to defect characteristics and intraoperative CSF leak severity.

METHODS

Search strategy PubMed, Embase, the Cochrane Library, and Web of Science were systematically searched for eligible studies published from 1996 through the end of April 2026. The search strategy combined controlled vocabulary (including MeSH terms where applicable) and free-text terms related to endoscopic endonasal approaches, cerebrospinal fluid leakage, and dural or skull base

reconstruction. Search concepts included "endoscopic endonasal," "endoscopic transnasal," "endoscopic transsphenoidal," "cerebrospinal fluid leak," "cerebrospinal fluid leakage," "dural repair," "dural reconstruction," and related terms. The search syntax was adapted for each database. In addition, the reference lists of eligible studies were manually screened to identify additional relevant publications.

Participant or population Patients with sellar, parasellar, or skull base lesions undergoing endoscopic endonasal approach (EEA) or extended endoscopic endonasal approach (EEEA) surgery requiring dural or skull base reconstruction. Eligible pathologies included pituitary adenomas/pituitary neuroendocrine tumors (PitNETs), craniopharyngiomas, Rathke's cleft cysts, meningiomas, and other skull base lesions treated through an endoscopic endonasal approach. No specific restrictions were applied regarding age or sex.

Intervention Dural and skull base reconstruction strategies performed following endoscopic endonasal approaches (EEA) or extended endoscopic endonasal approaches (EEEA). Interventions included inlay and/or onlay graft reconstruction, multilayer reconstruction using autologous or synthetic materials, vascularized nasoseptal flaps (NSFs), free mucosal grafts, dural suturing techniques, rigid buttress reconstruction, and adjunctive tissue sealants or surgical glues. Reconstruction strategies were evaluated according to intraoperative CSF leak severity and anatomical characteristics of the dural defect.

Comparator Alternative dural or skull base reconstruction strategies, including no reconstruction where applicable.

Study designs to be included Retrospective and observational studies, including cohort and case-control studies, evaluating dural or skull base reconstruction and postoperative CSF leak outcomes following EEA or EEEA were included. Case series with ≥10 patients were also eligible when sufficient data on reconstruction methods and postoperative CSF leakage were available.

Eligibility criteria Studies were required to report postoperative CSF leak incidence and provide sufficient information on dural or skull base reconstruction methods. Studies involving combined craniotomy and EEA, sinonasal procedures without dural opening or repair, non-human or cadaver/bench studies, and studies with insufficient CSF leak or reconstruction data were excluded. Meta-analyses, systematic reviews, case reports, technical notes, editorials, protocols, and case series with <10 cases were excluded. Studies with a Newcastle–Ottawa Scale score <5 were also excluded.

Information sources Electronic literature searches were conducted in PubMed, Embase, the Cochrane Library, and Web of Science for eligible studies published from 1996 through the end of April 2026. In addition, the reference lists of all eligible articles were manually screened to identify additional relevant studies not retrieved through the electronic database searches. No trial registries or other grey literature sources were systematically searched.

Main outcome(s) The main outcome was postoperative cerebrospinal fluid (CSF) leakage following endoscopic endonasal approach (EEA) or extended EEA (EEEA), as reported during postoperative follow-up in each included study. Postoperative CSF leakage was defined as CSF leakage from the nasopharynx confirmed by biochemical and/or imaging examinations. The incidence of postoperative CSF leakage was extracted for each reconstruction strategy. Comparative effectiveness was assessed using odds ratios (ORs) with 95% confidence intervals (CIs) in the frequentist random-effects network meta-analysis. A Bayesian random-effects network meta-analysis was performed as a sensitivity analysis, with ORs and 95% credible intervals (CrIs) reported.

Additional outcome(s) Additional outcomes included the types and components of skull base reconstruction according to intraoperative CSF leak severity and anatomical defect characteristics. These included the use of vascularized nasoseptal flaps, free mucosal or autologous tissue grafts, synthetic dural substitutes, dural suturing techniques, rigid buttress reconstruction, and adjunctive tissue sealants. Reconstruction strategies were descriptively evaluated according to low-, moderate-, and severe/high-flow intraoperative CSF leakage and the presence or absence of arachnoid violation. Study-level characteristics potentially associated with postoperative CSF leakage, including pathology, tumor size and extension, and body mass index, were also descriptively summarized when reported.

Data management Records retrieved from the electronic database searches were screened according to the predefined eligibility criteria. After study selection, three reviewers independently

reviewed the full texts and extracted prespecified study characteristics and outcome data. Extracted data included study characteristics, patient and tumor characteristics, intraoperative CSF leak classification, reconstruction techniques, postoperative CSF leak outcomes, and variables relevant to quality assessment. Data were organized in structured tabular form for descriptive synthesis and network meta-analysis. Methodological quality was independently assessed by two reviewers using the Newcastle–Ottawa Scale, with disagreements resolved by reassessment by a third reviewer.

Quality assessment / Risk of bias analysis Methodological quality of the included observational studies was assessed using the Newcastle–Ottawa Scale (NOS), applying the appropriate criteria for cohort and case-control studies. The NOS evaluates study quality across the domains of selection, comparability, and outcome/exposure assessment, with a maximum score of 9 points. Two reviewers independently assessed each study. Any disagreement between the two reviewers was resolved through reassessment by a third reviewer. Studies with an NOS score <5 were considered to have insufficient methodological quality and were excluded from the review.

Strategy of data synthesis Data were initially synthesized descriptively according to study characteristics, intraoperative CSF leak severity, anatomical defect characteristics, and reconstruction strategy. Because heterogeneous intraoperative CSF leak grading systems were used across studies, existing classifications were harmonized into low-, moderate-, and severe/high-flow categories to facilitate evidence synthesis. Comparative effectiveness of reconstruction strategies for preventing postoperative CSF leakage was evaluated using MetaInsight. A frequentist random-effects network meta-analysis was performed as the primary analysis, with no reconstruction as the reference treatment. Network geometry and consistency between direct and indirect evidence were examined. Treatment effects were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Given the limited number of comparative studies and sparse network structure, a Bayesian random-effects network meta-analysis was additionally performed as a sensitivity analysis, with treatment effects reported as ORs with 95% credible intervals (CrIs).

Subgroup analysis No formal subgroup network meta-analysis was performed because of the limited number of comparative studies, heterogeneous reporting, and sparse network structure. For descriptive subgroup synthesis, reconstruction strategies were stratified according to intraoperative CSF leak severity (low, moderate, and severe/high-flow) and anatomical defect characteristics, particularly the presence or absence of arachnoid violation. Patterns of reconstruction complexity and the use of vascularized flaps, grafts, suturing, rigid buttress techniques, and tissue sealants were compared descriptively across these categories.

Sensitivity analysis A Bayesian random-effects network meta-analysis was performed as a sensitivity analysis to examine the comparative treatment effects under an alternative statistical framework, given the limited number of comparative studies and sparse network structure. Treatment effects were expressed as odds ratios (ORs) with 95% credible intervals (CrIs) and compared with the direction and interpretation of estimates from the primary frequentist random-effects network meta-analysis. Because several Bayesian estimates showed extremely small posterior ORs and wide CrIs under sparse-data conditions, these results were interpreted cautiously.

Language restriction The search was restricted to studies published in English.

Country(ies) involved Japan and Taiwan.

Other relevant information This systematic review and network meta-analysis was retrospectively registered after completion of the review. At the time of registration, literature screening, data extraction, methodological quality assessment, descriptive synthesis, and network meta-analysis had been completed, but the manuscript had not been published. Prospective registration was not undertaken at the initiation of the review because the target journal had not yet been determined. This retrospective registration is intended to provide a transparent and publicly accessible record of the review methods and analyses. No changes to the completed review methods or analyses were made for the purpose of registration.

Keywords Endoscopic endonasal approach; cerebrospinal fluid leak; skull base reconstruction; nasoseptal flap; network meta-analysis; systematic review.

Dissemination plans The findings of this systematic review and network meta-analysis will be submitted for publication in a peer-reviewed

scientific journal and may also be presented at relevant national or international neurosurgical and skull base surgery meetings. The results are intended to inform clinical practice and future research on reconstruction strategies for preventing postoperative cerebrospinal fluid leakage following endoscopic endonasal skull base surgery.

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