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Endoscopic Skull Base Reconstruction of Large Dural Defects: A Systematic Review of Published Evidence

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Objectives/Hypothesis: Systematically review the outcomes of endoscopic endonasal techniques to reconstruct large skull base defects (ESBR). Such surgical innovation is likely to be reported in case series, retrospective cohorts, or case-control studies rather than higher level evidence.

Study Design: Systematic review and meta-analysis.

Methods: Embase (1980–December 7, 2010) and MEDLINE (1950–November 14, 2010) were searched using a search strategy designed to include any publication on endoscopic endonasal reconstruction of the skull base. A title search selected those articles relevant to the clinical or basic science of an endoscopic approach. A subsequent abstract search selected articles of any defect other than simple cerebrospinal fluid (CSF) fistula, sella only, meningoceles, or simple case reports. The articles selected were subject to full-text review to extract data on perioperative outcomes for ESBR. Surgical technique was used for subgroup analysis.

Results: There were 4,770 articles selected initially, and full-text analysis produced 38 studies with extractable data regarding ESBR. Of these articles, 12 described a vascularized reconstruction, 17 described free graft, and nine were mixed reconstructions. Three had mixed data in clearly defined patient groups that could be used for meta-analysis. The overall CSF leak rate was 11.5% (70/609). This was represented as a 15.6% leak rate (51/326) for free grafts and a 6.7% leak rate (19/283) for the vascularized reconstructions ($\chi^2 = 11.88$, $P = .001$).

Conclusions: Current evidence suggests that ESBR with vascularized tissue is associated with a lower rate of CSF leaks compared to free tissue graft and is similar to reported closure rates in open surgical repair.

Key Words: Systematic review, skull base, septal flap, cerebrospinal fluid leak, dura, pericranium, endoscopic surgery, reconstruction.

Level of Evidence: 3a.

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INTRODUCTION

There has been a rapid evolution of the approach to many ventral skull base pathologies in the last decade. The endoscopic route is now a preferred option for many surgical centers when managing both benign and malignant disease. Endoscopic transnasal transcranial surgery that is now performed was considered highly risky only 10 years ago. Much of the morbidity was associated with the inability to provide a consistent and robust separation of the cranial cavity from the paranasal sinus after the endonasal resection. The reported rates of cerebrospinal fluid (CSF) leaks were as high as 30% to 40%,[1] with significant complications such as meningitis, abscess formation, and ventriculitis. This was seen as an Achilles' heel for endoscopic skull base surgery with dural resections.[2]

The majority of small defects (<1 cm) in the skull base (most commonly encountered during CSF fistula closure following trauma and after iatrogenic injury) are reliably repaired using multilayered free grafts,[3] with rates of success >90% and minimal difference between methods or material used.[3,4] This provides good long-term prevention of further CSF leaks and intracranial infection.[5]

For larger skull base defects (>3 cm), materials used for free graft repairs have included turbinate mucosa,[6] cadaveric pericardium, acellular dermis,[7] fascia lata,[8] and titanium mesh.[9] In general, repair of larger defects with free grafting can lead to a higher rate of CSF leaks than smaller defects,[10] and surgery of larger defects allows unacceptably high leak rates (>30%).[7,11]

In response to these reconstructive failures, the use of local and regional vascularized flaps in the reconstruction of large skull base defects has provided a dramatic shift in our ability to manage such large defects between the cranial and sinonasal cavities. Local vascularized flaps have been developed that can be harvested, tailored, and used in endoscopic endonasal skull base

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surgery,[12–14] and increasingly these vascularized flaps are becoming the repair method of choice for endoscopic skull base reconstruction due to their ease of use, low donor site morbidity, and low complication rates.[13,15]

The aim of this study was to critically and systematically review the data available on the perioperative outcomes of published case series, cohorts, and case-control studies on endoscopic endonasal reconstruction of large dural skull base defects. The primary outcome was overall CSF leak rates in the postoperative period, and a secondary outcome was data stratification with comparison based on avascular grafting versus vascularize tissue reconstructions.

MATERIALS AND METHODS

A systematic review of published literature was performed for the primary outcome of CSF leak rates during endoscopic skull base surgery.

Eligibility Criteria

Published articles in English were eligible. All articles reporting original data on patients undergoing endoscopic skull base reconstruction were eligible, including those with any intervention for the treatment of specific pathologies, such as meningioma and craniopharyngioma, where a large defect would be anticipated. Because this review is of large skull base defects, outcomes of patients undergoing simple closure of CSF fistulae or encephaloceles were excluded because the vast majority of these defects are relatively small. Only studies where an endonasal craniotomy was created as part of a procedure were included. Trials included subjects of any age, with any comorbidity, and of varied duration of follow-up were included. Local and regional flap reconstructions of endonasal skull base surgery series were included. Case series, case-control studies, cohort studies, and randomized controlled trials were included.

Search Criteria

The MEDLINE database was searched from 1950 to November 14, 2010, and the Embase database was searched from 1990 to December 7, 2010. The Cochrane Collaboration database and the National Health Service, Evidence Health Information Resources Web site were also searched. The bibliographies of identified articles were also reviewed and used as an additional data source. No unpublished trials were included. We designed a search strategy to include articles relevant to any aspect of endoscopic surgery and skull base reconstruction. The search strategy used for Embase and MEDLINE databases is shown in Table I.

Once the searches were completed, study selection was performed by two authors (P.P. and R.J.H.) in an unblinded standardized manner. The publications extracted were grouped by title and obvious duplicates were excluded. The abstracts were then reviewed to ascertain whether they met the inclusion and exclusion criteria described above.

Data Extraction

Standardized data sheets were used for each study. Some studies included more than one patient reconstructive group (vascular vs. grafted repair). The primary outcomes were recorded as postoperative CSF leak closure. Secondary analysis of this outcome by reconstruction type was recorded. For each group, the type of reconstruction, pathology, number of patients, success of closure as defined by need for reoperation, and perioperative morbidity relevant to the reconstruction was recorded. The complications recorded included bleeding (epistaxis or intracranial), infectious complications (meningitis, subdural, or intracranial abscess and ventriculitis), persistent pneumocephalus, and any mortality related to the skull base surgery.

TABLE I.
MEDLINE Search Strategy*.

1	Nasal.mp. or Nasal Cavity/
2	nose.mp. or Nose/
3	paranasal sinus.mp. or Paranasal Sinuses/
4	(transnas$ or trans-nas$).mp.
5	(sinonasal or sino-nasal).mp.
6	endoscop$.mp.
7	Endoscopes/
8	Endoscopy/
9	(endonas$ or endosin$).mp.
10	or/1-9
11	Surgical Flaps/ or Reconstructive Surgical Procedures/ or Suture Techniques/
12	reconstruct$.mp.
13	defect.mp.
14	repair.mp.
15	closure.mp.
16	sealing.mp.
17	Cerebrospinal Fluid/su [Surgery]
18	Dura Mater/su [Surgery]
19	or/11-18
20	Ethmoid Sinus/ or Ethmoid Bone/ or ethmoid.mp.
21	Sphenoid Sinus/ or Sphenoid Bone/ or sphenoid.mp.
22	(clivus or clival).mp.
23	anterior cranial fossa.mp. or Cranial Fossa, Anterior/
24	middle cranial fossa.mp. or Cranial Fossa, Middle/
25	posterior cranial fossa.mp. or Cranial Fossa, Posterior/
26	(transethm$ or transsphen$ or transcliv$ or transplan$).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]
27	(trans-ethm$ or trans-sphen$ or trans-cliv$ or trans-plan$).mp. [mp=title, original title, abstract, name of substance word, subject heading word, unique identifier]
28	Craniotomy/ or craniotomy.mp.
29	craniectomy.mp.
30	Skull Base/ or skull base.mp. or skullbase.mp.
31	Brain Neoplasms/ or Pituitary Neoplasms/ or Skull Neoplasms/
32	Sella Turcica/ or Sella Turcica.mp.
33	or/20-32
34	10 and 19 and 33
35	limit 34 to english language

*Similar modified version used in Embase.

Management of Heterogeneity

The large range of methods, study aims, and pathologies were reported qualitatively in the data (Tables II–IV). Studies were deemed suitable for inclusion only if they described dural

TABLE II.
Characteristics of Included Studies by Endoscopic Reconstruction Type (Vascular Flap or Mixed).

Study	Year	Study Focus, Flap or Pathology	No.	No. With Defect	Repair Type	Age, yr (SD or Range)	% Female	Defect Size, Longest Axis	Defect Location	Lumbar Drain Use, % (Days)	Prior Radiotherapy
El-Sayed[28]	2008	Local flap, posterior septal	30	20	Vascular flap	52 (18–86)	50	1.86 cm^2	E, P, C, ITF	55 (4)	20%
Fortes[31]	2007	Local flap, ITF	4	4	Vascular flap	52.8 (4)	50	NR	C, P	NR	NR
Fortes[30]	2007	Regional flap, TPF	2	2	Vascular flap	NR	NR	NR	C	NR	100%
Hackman[34]	2009	Regional flap, palatal	1	1	Vascular flap	70	100	NR	C	NR	100%
Hadad[12]	2006	Local flap, posterior septal	43	43	Vascular flap	NR (22–74)	28	NR	F, E, P, C	NR	NR
Harvey[13]	2009	Local flap, septal and ITF	30	30	Vascular flap	45.5 (20.2)	43	24.9 mm	E, P, C, O	0	NR
Horiguchi[35]	2010	Local flap, posterior septal	21	14	Vascular flap	58 (20–78)	43	NR	P, C	7	NR
Kassam[37]	2008	Local flap, posterior septal	75	55	Vascular flap	47 (4–80)	37	NR	E, P, C, ITF, O	100 (4)	NR
Luginbuhl[41]	2010	Mixed benign and malignant neoplasms, CSF leak	16	16	Vascular flap	NR	NR	NR	E, P, C	25–50 (7)	NR
Madhok[42]	2010	Rathke cysts	35	3	Vascular flap	34 (12–67)	NR	NR	P	NR	NR
Nyquist[43]	2010	Mixed benign neoplasms	5	5	Vascular flap	56.4 (31–72)	60	NR	P, C	20 (1)	NR
Patel[44]	2010	Regional flap, pericranial	10	10	Vascular flap	NR	NR	NR	E, P	NR	30%
Shah[45]	2009	Local flap, posterior septal pediatric	6	6	Vascular flap	13 (2.5)	NR	NR	E, P	NR	NR
Stamm[46]	2008	Craniopharyngioma	4	4	Vascular flap	23.4 (16.3)	25	NR	E, P,C	0%	NR
Zanation[15]	2009	Local flap, posterior septal	70	70	Vascular flap	NR	NR	>20 mm in 60%	E, P, C	93 (3)	23%
Greenfield[33]	2010	Mixed benign and malignant neoplasms, CSF leak	44	33	Mixed	55.4 (17-85)	61	NR	F, E, P	NR	NR
Ceylan[19]	2009	Mixed benign and malignant neoplasms	13	13	Mixed	47 (12.3)	62	NR	E, P, C	31	NR
Cavallo[18]	2009	Craniopharyngioma	22	22	Mixed	49.4 (18–80)	32	NR	P	61	27%
Folbe[29]	2009	Olfactory neuroblastoma	23	19	Mixed: 1 flap, 18 free	56.6 (15–79)	30	NR	E, P	NR	NR
de Divitiis[25]	2008	Meningioma	11	11	Mixed: 3 flap, 8 free	56.1 (44–80	64	29.8 mm	E, P	NR	NR
Dehdashti[26]	2008	Chordoma	12	9	Mixed: 5 flap, 7 free	49.4 (15.8)	33	40.3 mm	C	NR	25%

SD = standard deviation; E = transethmoid/cribriform; P = transplanum; C = transclival; ITF = transpetrous, ptyergoid or infratemporal fossa; NR = not reported; TPF = temporparietal flap; O = trans-odontoid; CSF = cerebrospinal fluid.

TABLE III.
Characteristics of Included Studies by Endoscopic Reconstruction Type (Free Grafting).

Study	Year	Study Focus, Flap or Pathology	No.	No. With Defect	Repair Type	Age (SD or Range)	% Female	Defect Size (Longest Axis)	Defect Location	Lumbar Drain Use, % (Days)	Prior Radiotherapy, %
Batra[16]	2010	Mixed benign and malignant neoplasms	31	17	Free	57.5 (14–84)	42	16 mm	F, E, P	47	19
Cavallo[18]	2007	Suprasellar: Men, CP, AD, RC, glioma	21	21	Free	NR	NR	NR	P	5 (7)	5
Chen[20]	2006	Mixed malignant neoplasms	7	1	Free	52.7 (33–79)	29	NR	E, P	NR	NR
Church[21]	2003	Iatrogenic post-ESS defects	3	3	Free	43.7 (10.6)	0	>20 mm	E, P	67	0
de Divitiis[23]	2007	Suprasellar: Men, CP, AD, RC, AC	20	20	Free	49.5 (24–70)	55	NR	P	15	NR
de Divitiis[22]	2007	Craniopharyngioma	10	10	Free	57.2 (26–70)	40	52.8 mm^2	P	NR	NR
de Divitiis[24]	2007	Meningioma	6	6	Free	56.1 (44–70)	50	24.7 mm	P	0	0
El-Banhawy[27]	2008	Meningioma (from mixed group)	3	3	Free	42.5 (40–45)	0	14 mm	E, P	NR	NR
Esposito[9]	2007	Mixed: Men, CP, AD, Ch, RC, malignant neoplasms	620	58	Free	46 (5–86)	59	NR	P, C	100	NR
Gardner[1]	2008	Meningioma	35	35	Free	55 (39–79)	83	NR	E, P	100	6
Germani[32]	2007	Mixed benign and malignant neoplasms, CSF leak	56	55	Free	NR	NR	29% 4–20 mm, 29% >20 mm	E, P	20	NR
Horiguchi[35]	2010	Control patients: free grafts	11	10	Free	52 (27–79)	27	NR	E, P, C	90	NR
Kassam[36]	2007	Mixed benign and malignant neoplasms, CSF leak	25	11	Free	11.9 (5.3)	52	NR	E, P, C	NR	NR
Laufer[38]	2007	Suprasellar: Men, CP, RC	10	10	Free	54 (12.4)	NR	26.5 mm	P	50	NR
Leng[39]	2008	Mixed: Men, CP, Ch, CSF leak	10	10	Free	NR	NR	NR	E, P, C	50	10
Leong[40]	2006	Mixed benign and malignant neoplasms	14	10	Free	57.4 (26–84)	43	4–40 mm	E, P	70 (5)	29
Luginbuhl[41]	2010	Control patients: free grafts	24	24	Free	NR	NR	17 mm	E, P, C	33	NR
Stamm[46]	2008	Craniopharyngioma: free grafts	3	3	Free	23.4 (16.3)	33	NR	P	0	NR
Vergez[47]	2009	Adenocarcinoma	17	5	Free	68 (44–82)	0	NR	C, P	NR	NR
Villaret[48]	2010	Mixed malignant neoplasms	62	14	Free	61.7 (25–84)	29	NR	E, P	47	19

F = transfrontal; E = transethmoid/cribriform; P = transplanum; CP = craniopharyngioma; AD = adenoma; RC = Rathke's cyst;, NR = not reported; ESS = endoscopic sinus surgery; AC = astrocytoma; Ch = chordoma; C = transclival; CSF = cerebrospinal fluid; Men = meningioma.

TABLE IV.
Perioperative Outcomes of Included Studies by Endoscopic Reconstruction Type.

Study	Year	No.	No. With Defect	CSF Leak	Pneumocephalus	Epistaxis	Intracranial Bleed	Meningitis	Other Intracranial Infective	Sinusitis	PE/DVT	Mortality
Vascular flap reconstructions												
El-Sayed[28]	2008	30	20	0	0	0	1	0	0	0	0	0
Fortes[31]	2007	4	4	0	0	0	0	0	0	0	0	0
Fortes[30]	2007	2	2	0	0	0	0	0	0	0	0	0
Hackman[34]	2009	1	1	0	NR	NR	NR	NR	NR	NR	NR	0
Hadad[12]	2006	43	43	2	NR	1	0	0	0	0	NR	o
Harvey[14]	2009	30	30	1	0	2	0	0	0	1	0	0
Horiguchi[35]	2010	21	14	2	NR	NR	NR	NR	NR	NR	1	0
Kassam[37]	2008	75	55	8	NR	1	NR	0	0	NR	NR	0
Luginbuhl[41]	2010	16	16	1	NR	NR	NR	NR	NR	NR	NR	NR
Madhok[42]	2010	35	3	0	NR	NR	NR	NR	NR	NR	NR	0
Nyquist[43]	2010	5	5	0	NR	0	0	0	0	0	0	0
Patel[44]	2010	10	10	0	NR	NR	NR	NR	NR	NR	NR	0
Shah[45]	2009	6	6	1	NR	NR	NR	NR	NR	NR	NR	NR
Stamm[46]	2008	4	4	0	NR	0	0	0	0	0	0	0
Zanation[56]	2009	70	70	4	NR	NR	NR	NR	NR	NR	NR	0
Free graft reconstruction												
Batra[16]	2010	31	17	2	1	1	0	1	0	1	1	0
Cavallo[17]	2007	21	21	2	NR	NR	NR	0	NR	1	NR	0
Chen[20]	2006	7	1	0	NR	NR	NR	NR	NR	NR	NR	0
Church[21]	2003	3	3	0	0	0	0	0	0	0	0	0
de Divitiis[23]	2007	20	20	1	1	NR	NR	NR	NR	1	NR	NR
de Divitiis[22]	2007	10	10	2	0	0	2	0	0	1	NR	1
de Divitiis[24]	2007	6	6	2	NR	0	1	NR	NR	NR	NR	1
El-Banhawy[27]	2008	3	3	0	NR	NR	NR	NR	NR	NR	NR	0
Esposito[9]	2007	620	58	7	NR	NR	NR	2	NR	NR	NR	0
Gardner[1]	2008	35	35	14	1	NR	1	0	NR	1	3	0
Germani[32]	2007	56	55	3	0	1	0	0	1	0	NR	0
Horiguchi[35]	2010	11	10	3	NR	NR	NR	NR	NR	NR	NR	NR
Kassam[36]	2007	25	11	2	NR	NR	NR	0	NR	NR	NR	0
Laufer[38]	2007	10	10	1	NR	NR	NR	NR	NR	NR	NR	0
Leng[39]	2008	10	10	0	NR	NR	NR	NR	NR	NR	NR	0
Leong[40]	2006	14	10	0	NR	1	0	2	0	2	1	0
Luginbuhl[41]	2010	24	24	10	NR	NR	NR	NR	NR	NR	NR	0
Stamm[46]	2008	3	3	2	NR	0	0	0	0	0	0	0
Vergez[47]	2009	17	5	0	0	0	0	1	0	NR	0	0
Villaret[48]	2010	62	14	8	NR	NR	NR	1	0	NR	NR	0
Mixed reconstructions												
Greenfield[33]	2010	44	33	4	NR	0	NR	0	2	5	NR	0
Ceylan[19]	2009	13	13	5	NR	NR	1	NR	NR	NR	NR	1
Cavallo[18]	2009	22	22	3	0	0	0	0	0	1	0	0
Folbe[29]	2009	23	19	4	0	1	0	0	0	0	0	0
de Divitiis[25]	2008	11	11	3	0	0	1	0	0	0	0	1
Dehdashti[26]	2008	12	9	4	1	0	1	0	0	0	0	0

CSF = cerebrospinal fluid; PE/DVT = pulmonary embolus/deep vein thrombus; NR = not reported.

defect reconstructions or could providef enough information to separate extradural surgery from those that had obvious arachnoid to sinonasal communication. This ensured a study population that was not confounded by patients who did not have a significant risk of postoperative CSF leak.

Statistical Assessment

Statistical assessments were performed primarily with descriptive data. Case-by-case analysis was performed for summary data. Assessment of different pathologies was performed as nominal data and analyzed using χ^2 and Fishers

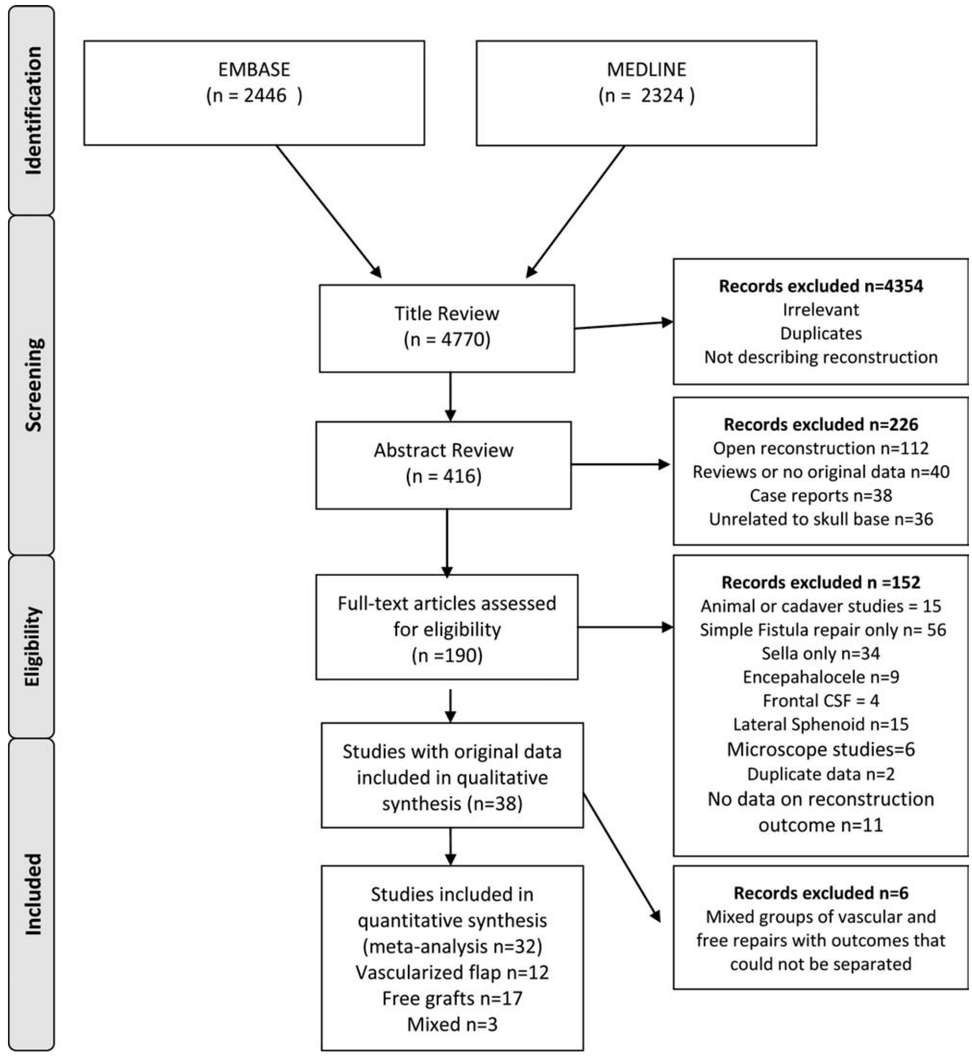

Fig. 1. Article selection process from the Embase and MEDLINE database searches.

exact tests via SPSS version 17 software (SPSS Inc., Chicago, IL).

RESULTS

The search of Embase and MEDLINE produced a total of 4,770 studies written in English. After exclusion of duplicates, 1,088 studies remained. A title search found 416 articles on skull base surgery. Of the 416 abstracts reviewed, 268 described endonasal skull base surgery. Of these, 40 (15%) were reviews of endoscopic or endonasal techniques and 38 (14%) were simple case reports. These studies were excluded from analysis. The selection process is outlined in Figure 1.

The abstract search found 190 articles directly relating endoscopic skull base repair or the management of conditions in which reconstruction would be required. Those studies that described sella-only reconstruction (n = 34), encephalocele management (n = 9), and unique locations of simple fistula (n = 9) were excluded. The full-text analysis produced 38 studies with extractable data regarding endoscopic skull base reconstruction with large dural defects.[1,9,12,15,16–49] Of these, 12 articles described a vascularized reconstruction,[12,13,15,28,30,31,34,37,42–45] 17 described free graft repairs,[1,9,16,17,20–24,27,32,37–40,47,48] and nine were mixed reconstructions.[13,18,19,25,26,29,33,35,41] Three of these had mixed data levels in clearly defined patient groups that could be used for comparison in this systematic review.[13,35,41]

The study characteristics of the 38 articles included are described in Tables I through IV. Perioperative outcomes were defined as CSF leak, revision surgery, infectious complications (meningitis, intracranial abscess, sinusitis), hemorrhagic complications (epistaxis, intracranial bleeding), thromboembolic events, respiratory events, and mortality. Of all these, only CSF leaks were consistently reported among all 38 studies.

CSF Leak Outcomes Results

There were 609 patients with large dural defect reconstructions included in the meta-analysis from the 38 articles. A total of 326 patients (54%) underwent a free graft reconstruction, and 283 patients (46%) had vascularized reconstruction. The overall rate of CSF leak was 11.5% (70/609). This was represented as a 15.6% leak rate (51/326) for free grafts and a 6.7% leak rate (19/283) for the vascularized reconstructions ($\chi^2 = 11.88$, $P = 0.001$).

TABLE V.
Intranasal and Regional Vascular Flaps Available for Skull Base Reconstruction.

Location	Vascular Tissue Flap	Pedicle	Comments/Limitations
Intranasal vascular tissue flap	NSF[13,54]	Sphenopalatine artery	Ideal for all skull base reconstructions
	ITF[14]	Inferior turbinate artery*	Good for small clival defects, cannot reach ACF or sella
	MTF[55]	Middle turbinate artery*	Good for small ACF or transphenoidal defects, small in size, thin mucosa, difficult to elevate
Regional vascular tissue flap	PCF[44]	Supraorbital and supratrochlear artery	Hearty flap with versatile dimensions, extends from ACF to sella but not to posterior skull base
	TPFF[30]	Superficial temporal artery	Good for clival or parasellar defects, 90° pedicle rotation limits reconstruction of ACF
	PF[34]	Greater palatine artery	Theoretical flap that reaches all areas of skull base, 3-cm pedicle but difficult to dissect, experience

*Terminal branch of posterior lateral nasal artery of the sphenopalatine artery.

NSF = nasoseptal flap; ITF = inferior turbinate flap; ACF = anterior cranial fossa; MTF = middle turbinate flap; PCF = pericranial flap; TPFF = temporoparietal fascia flap; PF = palatal flap.

The included studies stratified by reconstruction type are listed in Table IV. The vascularized reconstruction group compares favorably to the published rates in a report of an international collaborative study on craniofacial surgery (6.5%–25%).[49]

Other Complications

Only CSF was routinely reported from the included studies. The reported nonleak perioperative morbidity is described in Table IV. However, the lack of uniform reporting makes for an unreliable meta-analysis and is reported as descriptive only.

DISCUSSION

Early reconstructive techniques in skull base surgery evolved from endoscopic repair of defects following spontaneous CSF leaks and accidental or iatrogenic trauma. Many articles and a meta-analysis have validated the reconstruction of small CSF fistulas, with a wide variety of free grafting techniques achieving success in more than 95% of patients that can be successfully revised if necessary.[3,5] The application of such techniques to the larger defects, as a result of intradural procedures, proved to be inadequate. Additional layering and collagen matrixes had reduced the CSF leak rate, but failure remained unacceptably high.[7,11,50]

Larger defects pose additional challenges of a wide dural resection, intra-arachnoid dissection, and exposure to high-flow CSF within the cisterns. But perhaps the most significant influence is the larger nonvascularized reconstructive bed—CSF on one side and sinus cavity (air) on the other. The posteriorly pedicled septal flap is the workhorse of most endoscopic intradural skull base surgery.[13,51] Other vascular pedicled flaps provide alternatives to address skull base defects of various sizes and locations when the posterior septal flap is unavailable. A summary of these vascularized local and regional flap options and limitations are summarized in Table V.

The endonasal approach may appear attractive to many anteriorly based pathologies. However, there is associated sinonasal morbidity associated with such an approach. Although endoscopic skull base surgery differs greatly from functional endoscopic sinus surgery, the final cavity left behind from the approach still needs to be functional. Crusting and short-term nasal morbidity is likely to be underreported in trials. de Almeida et al. reported nasal crusting the most common (98%) symptom, followed by nasal discharge (46%), whereas loss of smell was reported by only 9.5% of patients.[52] Crusting was short lived, with half of the patients achieving a crust-free nose by 101 days (95% confidence interval, 87.8-114.2 days).[52] Sinonasal function does appear to improve over time for these patients.[53] Loss of smell is often permanent, and although olfactory loss may be the consequence of an open approach, the risk should be considered when choosing the endonasal route.

Advancements in endoscopic skull base reconstruction have evolved with the ever-increasing size and complexity of lesions that are approached and resected. The principles of multilayer reconstructions and the routine use of vascularized flaps in expanded endonasal surgery have reduced postoperative CSF leak rates of between 5% and 10% (6.7% in this meta-analysis). In this review, vascularized skull base reconstructions for large dural defects had a clear and significant ($P = .001$) advantage over free grafting in the prevention of postoperative CSF leaks. Future advances will help us to understand and manage patients at high risk for a postoperative CSF leak, especially those who have been previously irradiated and/or require revision surgery. Additionally, our knowledge of reconstruction donor site morbidity, sinonasal quality of life, and methods to reduce patient postoperative recovery will continue to advance.

CONCLUSION

Current evidence in this systematic review suggests that skull base repair with vascularized tissue is associated with a lower rate of CSF leak compared to free tissue graft and is similar to reported closure rates in open surgical repair.

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