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Review Article

Cortical incisions and transcortical approaches for intra-axial and intraventricular lesions: A scoping review

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ABSTRACT

Background: Transcortical approaches, encompassing various surgical corridors, have been employed to treat an array of intraparenchymal or intraventricular brain pathologies, including tumors, vascular malformations, infections, intracerebral hematomas, and epileptic surgery. Designing cortical incisions relies on the lesion location and characteristics, knowledge of eloquent functional anatomy, and advanced imaging such as tractography. Despite their widespread use in neurosurgery, there is a noticeable lack of systematic studies examining their common lobe access points, associated complications, and prevalent pathologies. This scoping review assesses current evidence to guide the selection of transcortical approaches for treating a variety of intracranial pathologies.

Methods: A scoping review was conducted using the PRISMA-ScR guidelines, searching PubMed, EMBASE, Scopus, and Web of Science. Studies were included if ≥5 patients operated on using transcortical approaches, with reported data on clinical features, treatments, and outcomes. Data analysis and synthesis were performed.

Results: A total of 50 articles encompassing 2604 patients were included in the study. The most common primary pathology was brain tumors (60.6%), particularly gliomas (87.4%). The transcortical-transtemporal approach was the most frequently identified cortical approach (70.48%), and the temporal lobe was the most accessed brain lobe (55.68%). The postoperative course outcomes were reported as good (55.52%), poor (28.38%), and death (14.62%).

Conclusion: Transcortical approaches are crucial techniques for managing a wide range of intracranial lesions, with the transcortical-transtemporal approach being the most common. According to the current literature, the selective choice of cortical incision and surgical corridor based on the lesion's pathology and anatomic-functional location correlates with acceptable functional outcomes.

Keywords: Intracranial lesions, Surgical approach, Transcortical approaches, Transcortical transtemporal

INTRODUCTION

Transcortical approaches, which involve a wide variety of surgical corridors, have long been utilized to address a diverse range of cranial pathologies.[10,11,26,34] These techniques

include but are not limited to transcortical temporal, transcortical transventricular, and transcortical transfrontal approaches.[1,2,34,37] Such approaches have proven effective in managing conditions such as brain tumors, epilepsy, arteriovenous malformations (AVMs), and intracerebral hematomas, among others.[6,14,33] Transcortical incisions provide several advantages, such as immediate access to deeper brain regions and the capacity to customize the approach based on each patient's unique anatomy and pathology. Those methods can be particularly valuable when managing intricate intraparenchymal or intraventricular lesions. The transcortical approach also carries some limitations, including the possibility of transgressing functional cortices and subcortical areas, postoperative complications, and the requirement for a detailed understanding of brain anatomy to minimize potential consequences. Carefully considering the detailed advantages and disadvantages is crucial to selecting the most suitable transcortical entry point and operative corridor for each patient.

Despite the widespread use of transcortical approaches in the field of neurosurgery, there remains a notable scarcity of systematic studies examining their common lobe access points, associated complications, and prevalent pathologies. This scoping review endeavors to fill this knowledge gap by analyzing the available evidence, offering neurosurgeons effective guidance while selecting the most appropriate transcortical approaches for managing a broad spectrum of intracranial lesions.

MATERIALS AND METHODS

Literature search

A scoping review was performed using the PRISMA-ScR guidelines.[36,49] PubMed, EMBASE, Scopus, and Web of Science were searched from database inception to September 27, 2022, utilizing the combination of Boolean operators "OR" and "AND" and search terms: "transcortical," "transsulcual," "transgyral," and "transventricular." Studies were uploaded to Rayyan, and duplicates were deleted.

Study selection

The inclusion and exclusion criteria were pre-determinedly set. Studies were included that (1) involved ≥5 patients who were operated on using the transcortical approaches, as explicitly mentioned by the authors; (2) reported parameters on clinical presentation, anatomy-based operative approaches, and outcomes; (3) and were written in English. Studies were excluded if they were as follows: (1) reviews, conference abstracts, animal studies, cadaveric studies, or autopsy reports; (2) studies with an unclear distinction between patients using transcortical approach or not; and (3) studies lacking data on ≥2 of clinical characteristics, approaches, and/or outcomes. In the case of studies with overlapping cohorts, only those with the longest follow-up period were included in the study.

Two independent reviewers (M.I. and A.M.) evaluated the titles and abstracts of all obtained articles before assessing the complete texts of those that met the inclusion criteria. A third reviewer (P.P.) arbitrated any conflicts. Articles that met the inclusion criteria were added, and references were examined to identify additional relevant studies.

Data extraction

Data were extracted by two reviewers (M.I. and A.M.) and confirmed by one additional reviewer (P.P.). The authors did not report missing data. Extracted data included author and year of the study, level of evidence, cohort size, age, gender, primary pathology, side, surgical position, nomenclature of the approach, brain lobe access, anatomy of incision, length of incision, intraoperative tools, duration of the surgery, and postoperative course.

Data synthesis, quality assessment, and statistical analysis

Primary outcomes of interest were outcomes in selected patients who underwent surgery with cortical incision approaches. Two independent reviewers (M.I. and A.M.) assessed the level of evidence for each publication based on the 2011 Oxford Centre For Evidence-Based Medicine recommendations and the risk of bias based on the Joanna Briggs Institute checklists for case reports and case series.[20,31] Continuous variables are summarized as medians and ranges, and categorical variables as frequencies and percentages.

RESULTS

Study selection

Figure 1 demonstrates the study selection process. The initial search yielded 4703 citations (PubMed: 1423; EMBASE: 2181; Scopus: 729; Web of Science: 370). A total of 50 articles were included after the full-text screen. All the included are cohort studies, categorized IIIB of evidence [Table 1]. Critical assessment returned a low risk of bias for all included studies, rendering this review a low overall risk of bias [Supplementary File 1].

Demographics and clinical characteristics

Table 1[3-19,21-30,32-35,37-48,50-57] summarizes the demographics, pathology, and surgical anatomy of all 2604 pooled patients. Age ranged from 5 to 80 years, with a male prevalence of 57.78% [Table 2]. Patients experienced various pathologies, most commonly brain tumors (60.6%), classified based on their size and type. Lesion laterality was reported in

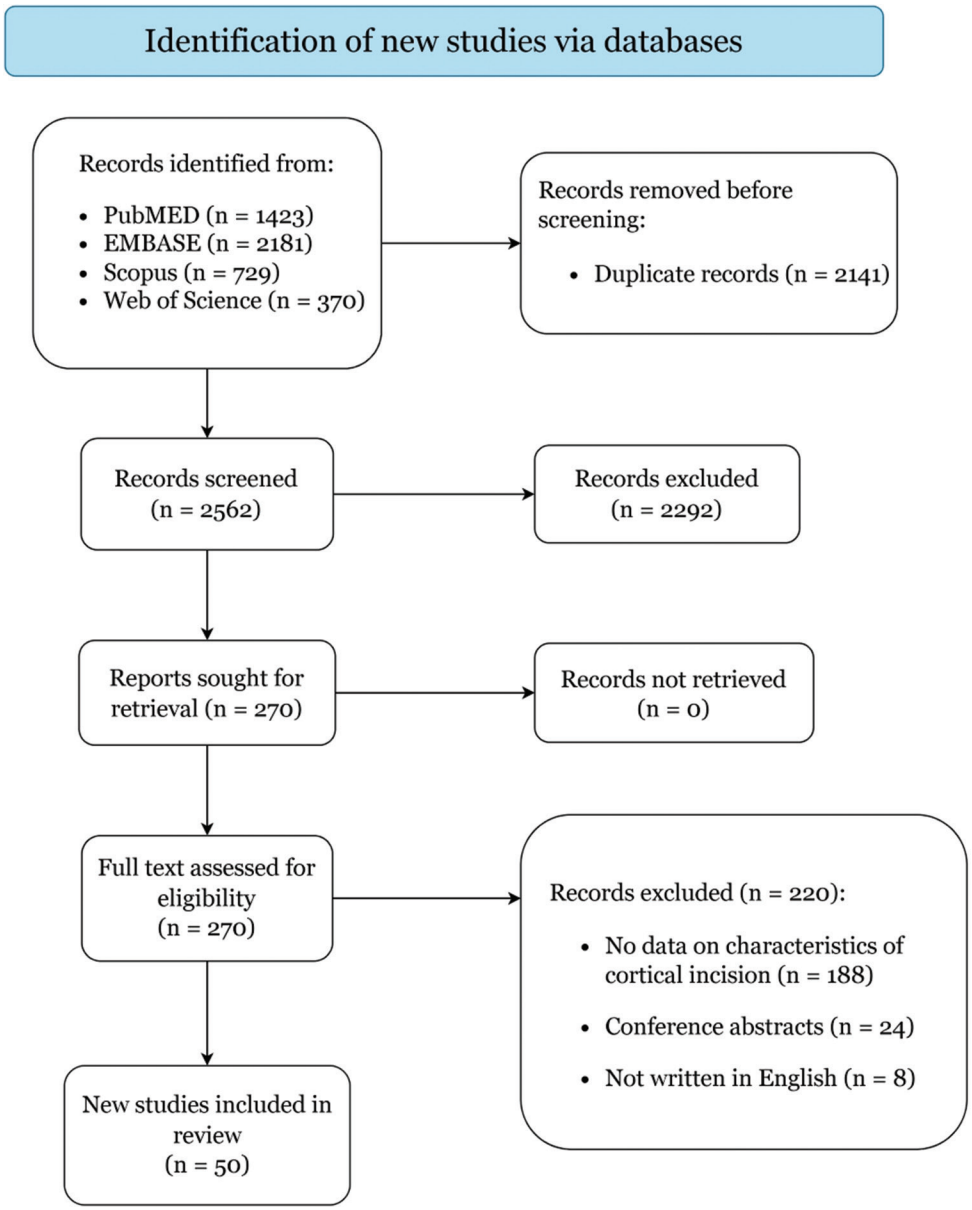

Figure 1: PRISMA flow chart of the studies.

1237 cases, most frequently located on the left side (57.15%), followed by the right side (42.84%). The brain tumors were classified according to the site (59.7%) and type (40.29%). The most frequent location was intraventricular tumors (63.53%), especially the lateral ventricle (70.45%), with involvement of the frontal horn and the area around the foramen of Monro tumors in 35.98% of the cases that are located in the lateral ventricle. The 3rd ventricle was affected in 23.17% of cases. Gliomas were the most common tumor type (87.4%).

Other pathologies include epilepsy (16.87%), intracerebral hematoma (11.97%), and brain AVMs (8.12%). Most lobar AVMs (63.75% of all AVM cases) were in the temporal area (60.27%), followed by the basal ganglia, thalamus, and insula (35.61%). Furthermore, paraventricular and intraventricular AVMs (36.24% of all AVM cases) were observed, with peri-trigonal (medial) AVMs representing 57.83% of cases and trigonal AVMs making up 31.32% of cases. Cavernomas were treated in 1.6% of cases, with 62.22% of them being supratentorial. Intraventricular cysticercosis was found in 0.75% of cases. Figure 2 summarizes the main brain lesions that transcortical routes can access.

Management strategies

The surgical position of the patients was mostly supine (95.99%). Treatment strategies are reported in Table 3. The

Table 1: Overview of the included studies.

ID	Authors, year	Level of Evidence	Cohort size	Age (median) Age (range)	Gender	Primary pathology	Side	Surgical position	Name of approach	Brain Lobe access	Anatomy of incision	Length of incision	Intraoperative tools	Duration of surgery	Postoperative course
1	Ignacio *et al.*[22] 1983	IIIB	21	32 Y 21–60 Y	6 F, 15 M	Intraventricular cysticercosis	3 R and 4 L	NR	Transcortical-frontal exploration of 3rd ventricle and Transcortical frontal trans-Morno exploration	Frontal (not specified)	Direction not specified	NR	Microscope	NR	11 (52%) Excellent, 4 (19%) Good, 4 (19%) Poor, 2 (10%) Death
2	Carmel[8] 1985	IIIB	100	NR NR	NR	Third ventricle tumors	NR	NR	Transcortical-Transventricular approach	Frontal (middle frontal gyrus)	Parallel to gyrus	NR	Microscope, but not all the cohort	NR	4 (4%) death, hemiparesis, and meningitis (1% incidence)
3	Hoi[19] 1985	IIIB	9	NR 12–60 Y	3 M, 6 F	Paraventricular and intraventricular AVMs	5 R and 4 L	NR	Transventricular approach through middle frontal gyrus, Transventricular approach through middle temporal gyrus, Transventricular approach through inferior temporal gyrus	Middle frontal gyrus/middle, Inferior temporal gyri	Direction not specified	NR	Microscope	NR	Transcortical approaches (6 cases): 5 have a good prognosis, and one poor one.
4	Waga[53] 1986	IIIB	4	NR 11–33 Y	M	Head of Caudate AVMs	3 R	NR	Transcortical-Transfrontal approach	Middle frontal gyrus/middle temporal gyrus	Parallel to gyrus	NR	NR	NR	2 excellent, and 1 poor
5	Schijman *et al.*[42] 1990	IIIB	10	NR 11 Months–11 Y	8 M, 2 F	3rd ventricle choroid plexus papilloma	NR	NR	Transcortical-Transfrontal approach	Frontal (not specified)	Direction not specified	NR	NR	NR	7 good prognosis, and 2 deaths
6	Pendl *et al.*[38] 1992	IIIB	55	NR 10–70 Y	30 M, 25 F	Lateral ventricle tumors	NR	NR	Transcortical-frontal/ transcortical-parieto-occipital/Transcallosal approach/anterior middle temporal gyrus incision	Middle frontal/angular gyrus/middle temporal gyri, tempro-occipital gyrus/ parieto-occipital sulcus	Parallel to gyrus	NR	NR	NR	Death 5.5% either due to postoperative hemorrhage or uncontrollable brain edema
7	Barrow and Dawson,[4] 1994	IIIB	26	31 Y 13–66 Y	12 M, 14 F	AVMs in the region of ventricular trigone	8 R and 7 L	NR	Lateral temporal approach/interhemispheric approach/transcortical approach	Middle, Inferior temporal gyri/parieto-occipital sulcus	Temporal (parallel to gyri), occipital (perpendicular)	Temporal (2 cm), and 2 cm parieto-occipital	Microscope and intraoperative ultrasound	NR	1 hemianopia, 3 no complications
8	Roszkowski *et al.*[40] 1995	IIIB	6	10.5 Y 7–15 Y	NR	Intraventricular tumors	5 R and 1 L	NR	Frontal transcortical approach	Frontal (not specified)	Direction not specified	NR	NR	NR	Good results in all 6 cases
9	Villemure and Mascott,[50] 1995	IIIB	11	NR 2–32 Y	4 M, 7 F	Hemi megalencephaly, infantile hemiplegia, chronic encephalitis, meningitis	NR	Supine	Peri-insular hemispherectomy	Superior circular sulcus of insula/superior temporal gyrus	Perpendicular to the insula/ temporal (not specified)	NR	NR	NR	1 postoperative hydrocephalus, 2 decreased seizure frequency, 11 improved
10	Kikuchi *et al.*[25] 1997	IIIB	9	NR 19–59 Y	7 M, 2 F	AVMs of the posterior hippocampus	3 R and 3 L	Lateral position	Laterobasal approach (Transoccipitotemporal sulcus approach)	Occipitotemporal sulcus/ Fusiform gyrus	Parallel to gyrus	NR	NR	NR	5 good recovery, 3 moderate disability, 1 severe disability
11	Gökalp *et al.*[15] 1998	IIIB	112	20.5 Y 4–67 Y	71 M, 41 F	Tumors of the lateral ventricle	NR		Anterior transcortical, posterior transcortical, temporal transcortical, occipital transcortical	Middle frontal gyrus/superior parietal lobule/middle, inferior temporal gyrus	Parallel to gyrus	NR	NR	NR	79.5% improved, 20.5% complications
12	Nair *et al.*[33] 1999	IIIB	48	28 Y 5–57 Y	33 M, 15 F	AVMs in the medial paratrigonal area	NR	NR	Transcortical resection	Parieto-occipital sulcus/ occipital pole	Sulcus (parallel to gyrus)/ pole (perpendicular to gyrus)	NR	NR	NR	17 excellent, 21 good, 2 fair, 2 poor
13	Olivier[34] 2000	IIIB	150	NR	NR	Bitemporal epilepsy	NR	NR	Transcortical selective amygdalohippocampectomy	Middle temporal gyrus	Parallel to gyrus	3 cm (temporal)	MRI-based frameless stereotaxy	NR	81% class 1, 8% class 2,4% class 3, 7% class 4, 0% class 5
14	Shimizu and Maehara,[47] 2000	IIIB	34	NR	NR	NR	NR	Supine	Modified peri-insular hemispherectomy	Frontal, parietal operculum	Parallel to gyrus	NR	Microscope	NR	4% Seizures

(Contd...)

Table 1: *(Continued).*

ID	Authors, year	Level of Evidence	Cohort size	Age (median) Age (range)	Gender	Primary pathology	Side	Surgical position	Name of approach	Brain Lobe access	Anatomy of incision	Length of incision	Intraoperative tools	Duration of surgery	Postoperative course
15	Ellenbogen,[11] 2001	IIIB	29	NR 3–35 Y	15 M, 14 F	Lateral ventricle tumors	NR	NR	Transcortical approach	Middle frontal, temporal gyri/superior parietal gyrus/ occipitotemporal gyrus/ supramarginal/occipital pole	Occipital (perpendicular to gyrus)/rest (parallel to gyrus)	NR	Microscope	NR	86% good, 14% fair, 6.9% poor
16	Miyagi *et al.*[30] 2002	IIIB	7	36.4 Y 18–54 Y	3 M, 4 F	Intractable mesial temporal lobe epilepsy	3 L and 4 R	Supine	Amygdalohippocampectomy	Inferior temporal sulcus Gyrus.	Parallel to gyrus	2 cm (temporal)	Microscope	NR	NR
17	Ozek and Ture,[35] 2002	IIIB	18	NR 2–16 Y	10 M, 8 F	Thalamic tumors	NR	NR	Transcortical trastemporal	Superior temporal sulcus	Parallel to gyrus	NR	NR	NR	6 Dead patients with malignant
18	Asgari *et al.*[3] 2003	IIIB	38	44 Y 5 D–71 Y	18 M, 20 F	Intra and periventricular supratentorial tumors, AVMs and cysts	NR	NR	Transcortical/transcallosal	Middle frontal gyrus	Direction not specified	NR	Microscope	NR	mortality 0%, hemiparesis 7%, transient mutism 11%, diencephalic injury 22%, seizures 26%, subdural hematoma 30%
19	Helmstaedter *et al.*[18] 2004	IIIB	34	NR NR	NR	Mesial temporal lobe epilepsy	10 R and 5 L	NR	Transcortical amygdalohippocampectomies approach	Middle temporal gyrus	Direction not specified	3 cm (temporal)	Microscope	NR	NR
20	Lutz *et al.*[27] 2004	IIIB	80	36.76 Y (mean) 16–60 Y	40 M, 40 F	Mesial temporal lobe epilepsy	18 R and 21 L	NR	Transcortical approach through the middle temporal gyrus	Middle temporal gyrus	Direction not specified	2 cm (temporal)	Microscope, Neuronavigation	NR	30 (76.9%) patients with seizures
21	Schaller *et al.*[41] 2004	IIIB	80	38 Y (mean) 13–58 Y	40 M, 40 F	Mesial temporal lobe epilepsy	NR	NR	Transcortical approach through the middle temporal gyrus	Middle temporal gyrus	Direction not specified	NR	Neuronavigation system	NR	Ipsilateral increases of blood flow velocities within the basal cerebral arteries.
22	Mittal *et al.*[29] 2005	IIIB	109	13.2 Y 2 M–18.9 Y	57 M, 52 F	Temporal lobe epilepsy	36 R and 31 L	NR	Transcortical- selective amygdalohippocampectomy, transcortical-selective amygdalohippocampectomy with lesionectomy	Gyrus not specified	Direction not specified	NR	Neuronavigation	NR	4 patients with seizures
23	Schramm and Aliashkevich,[43] 2008	IIIB	235	35 Y (mean) NR	131 M, 104 F	Temporomediobasal tumors	124 R and 112 L	NR	Transcortical approach	Superior, middle, inferior temporal gyri	Direction not specified	NR	Microscope	NR	Quadrantanopia in 4 cases
24	Seçer *et al.*[44] 2008	IIIB	46	36 Y (mean) 2–71 Y	26 M, 20 F	Lateral ventricle tumors.	NR	NR	Transcortical- trans frontal through middle frontal gyrus, transtemporal through middle temporal gyrus, and trans parietal approaches	Middle frontal gyrus/middle temporal gyrus/superior parietal lobule	Direction not specified	NR	Microscope	NR	NR
25	von Lehe and Schramm.[52] 2009	IIIB	34	42 Y (mean) 12–69 Y	20 M, 14 F	Gliomas arise from the cingulate gyrus.	12 R, 22 L	NR	Transcortical approach	Cingulate gyrus	Direction not specified	NR	Intraoperative electrophysiological monitoring and neuronavigation	NR	Speech disturbances
26	Zhou *et al.*[56] 2008	IIIB	17	41.24 Y (mean) 17–65 Y	6 M, 11 F	Paracentral cavernoma	8 R and 9 L	Supine	Transsulcal approaches (trans central sulcus in 6, transprecentral sulcus in 6 and transpostcentral sulcus in 5 patients)	Central sulcus/precentral and post central sulci	Parallel to gyrus	1 cm (temporal)	Neuronavigation, functional mapping and Neurophysiological intraoperative monitoring.	NR	5 patients with motor dysfunction
27	Daglioglu *et al.*[9] 2010	IIIB	11	40 Y (mean) 19–69 Y	6 M, 5 F	Supratentorial cavernomas	NR	NR	Transsulcal approach	Not specified	Direction not specified	NR	NR	NR	Seizures

(Contd...)

Table 1: *(Continued).*

ID	Authors, year	Level of Evidence	Cohort size	Age (median) Age (range)	Gender	Primary pathology	Side	Surgical position	Name of approach	Brain Lobe access	Anatomy of incision	Length of incision	Intraoperative tools	Duration of surgery	Postoperative course
28	Juretschke *et al.*[23] 2010	IIIB	20	42 Y (mean) 1–74 Y	8 M, 12 F	Lesions of trigone of the lateral ventricle	12 R and 8 L	Lateral and one prone position, one semi-sitting position	The posterior parietal transcortical approach (P1) in 13 cases (65%). A posterior middle temporal gyrus transcortical access (T2) in seven cases (35%).	Middle temporal gyrus/ superior parietal lobule	Parallel to gyrus	2 cm (temporal)	Neuronavigation System (BrainLAB, Heimstetten, Germany) in 13 cases, ultrasound in two cases	NR	According to the modified Rankin scale (mRS), 13 patients improved, five remained the same, and two were lost to follow-up. One patient had an increased visual field deficit and new hemiparesis and aphasia.
29	Thudium *et al.*[48] 2010	IIIB	12	NR 15–49 Y	5 M, 7 F	Mesial temporal lobe epilepsy	3 R and 9 L	Horizontal head position	Basal transcortical approach through the T3 gyrus	Inferior temporal gyrus/ fusiform gyrus	Parallel to gyrus	1.5 cm (temporal)	Navigation-bound operating microscope	NR	Peripheral incomplete superior quadrantanopia (1 patient)
30	Broadway *et al.*[5] 2011	IIIB	10	NR 3–15 Y	5 M, 5 F	Tumors of the thalamopeduncular region	NR	NR	Transcortical, middle temporal gyral approach and frontal transcortical	Middle temporal gyrus	Parallel to gyrus	NR	NR	NR	NR
31	Shi *et al.*[46] 2011	IIIB	18	28.67 Y (mean) 18–48 Y	12 M, 6 F	Central neurocytoma	NR	NR	Transcortical frontal approach	Gyrus not specified	Direction not specified	NR	NR	NR	Memory disorders, impairment of abstract summarization, anxiety and depression.
32	Park *et al.*[37] 2012	IIIB	12	28.5 (mean) 18–62 Y	8 M, 4 F	Central neurocytoma	6 R and 6 L	Supine position	Transcortical frontal approach through middle frontal gyrus	Middle frontal gyrus	Parallel to gyrus	NR	Intraoperative navigation system and intraoperative ultrasound.	NR	Single recurrence (2 patients). The Karnofsky performance Status (KPS) score at the 1–year follow-up was 100 in five patients, 90 in six patients, and 80 in one patient.
33	Gabarrós Canals *et al.*[13] 2013	IIIB	88	39 Y (mean) 6–77 Y	42 M, 46 F	Temporal lobe AVMs	29 R and 59 L	NR	Transcortical-temporal approach	Inferior temporal gyrus/ occipitotemporal gyrus	Direction not specified	NR	Intraoperative stimulation mapping	NR	According to mRS Scores, 15 patients with score 0, 26 patients with score 1, 8 patients with score 2, 2 patients with score 3, 3 patients with score 4, and 4 cases with score 6.
34	Mazher *et al.*[28] 2013	IIIB	33	26 Y (mean) 10 M– 56Y	23 M, 10 F	Intraventricular tumors	NR	NR	Open transcortical trans-lateral ventricular approach	Gyrus not specified	Direction not specified	NR	NR	NR	Good in 24 out of 33 cases (73%), and in 8 cases (24%) it was fair. One patient who died was categorized as having a poor outcome.
35	Potts *et al.*[39] 2013	IIIB	48	31 Y (mean) NR	27 M, 21 F	AVMs of the basal ganglia, thalamus, and insula	NR	Supine and semilateral	Transcortical approaches (trans frontal, transtemporal, or trans parietal)	Middle and inferior temporal gyri/superior parietal lobule/ middle frontal gyrus	Parallel to gyrus	NR	Microscope and neuronavigation	NR	NR
36	Wang *et al.*[54] 2013	IIIB	80	54.2 (mean) 39–77 Y	49 M, 31 F	Intracerebral hematoma	NR	NR	Transcortical-transtemporal approach	Superior, middle temporal gyri/insular gyri	Direction not specified	1 cm (temporal)	Microscope	NR	1 patient recovered from daily activities and was able to work; 8 recovered from family activities; 9 could walk with crutches or other support but needed care from others; 5 were bed-bound for a long; and 12 died.
37	Zhang *et al.*[55] 2013	IIIB	33	NR 47–80 Y	26 M, 7 F	Hypertensive putaminal hemorrhage	22 R and 11 L	Supine	Transcortical-transtemporal approach through the middle or inferior temporal lobe/2cm incision in the thinnest part of the cortex adjacent to the hematoma	Middle, inferior temporal gyri/insular gyri	Direction not specified	2 cm (temporal)	NR	4.14±0.59 hours	3 patients with good recovery, 3 patients with moderate disability, 2 patients with severe disability, 5 patients with vegetative state, and 6 Dead.
38	Faust *et al.*[13] 2014	IIIB	105	NR NR	65 M, 40 F	Temporal lobe tumors	52 R and 53 L	NR	Transcortical-temporal approach and pterional transcortical approach	Middle, superior temporal gyri	Direction not specified	NR	NR	NR	Aphasia (4 patients), and one case with Clinical vasospasm

(Contd...)

Table 1: *(Continued).*

ID	Authors, year	Level of Evidence	Cohort size	Age (median) Age (range)	Gender	Primary pathology	Side	Surgical position	Name of approach	Brain Lobe access	Anatomy of incision	Length of incision	Intraoperative tools	Duration of surgery	Postoperative course
39	Hussain *et al.*[21] 2014	IIIB	11	21 Y 10–27 Y	7 F, 4 M	Intraventricular tumors	NR	NR	Transcortical trans ventricular approach,	Lobe/gyrus not specified	Direction not specified	NR	Image guidance system	NR	6 (55%) Good, 4 (36%) Fair, 1 (9%) Poor
40	Gao *et al.*[14] 2016	IIIB	106	56 Y 25–80 Y	G1 (31 M, 20 F), G2 (36 M, 19 F)	hypertensive hemorrhage in the basal ganglia	NR	NR	G1 (Transcortical- sulcus approach), G2 (the traditional transcortical- transtemporal approach)	Superior temporal sulcus/ superior, middle temporal gyrus	Sulcus (parallel to gyrus)/ gyri (not specified)	NR	Microscope	G1 (2–30 h), G2 (2–36 h)	Seizures (13 patients) and Death (4 patients)
41	Morshed *et al.*[32] 2019	IIIB	50	46.8 Y NR	9 F, 41 M	Glioma	32 (64%) L, 18 (36%) R	NR	Transcortical equatorial approach	Middle, inferior, superior temporal gyri	Direction not specified	NR	NR	NR	Nil
42	Zhu *et al.*[57] 2017	IIIB	15	9.21 Y 6–16 Y	7 F, 8 M	Lateral ventricular tumor	11 L, 4 R	NR	Frontal transcortical approach	Middle frontal gyrus	Parallel to gyrus	NR	NR	NR	Cognitive deficits
43	Hameed *et al.*[16] 2019	IIIB	255	NR 20–78 Y	94 F, 161 M	Insular gliomas	145 (56.86%) L	supine.	Transcortical approach	Inferior frontal gyrus/superior temporal gyrus	parallel to gyrus	NR	Imaging–guided	NR	72 (29.15%) patients had died
44	He *et al.*[17] 2019	IIIB	30	NR 6–16 Y	13 F, 7 M	Intraventricular benign tumors	21 L, 9 R	NR	Frontal transcortical approach or transcallosal approach	Middle frontal gyrus	Parallel to gyrus	NR	NR	NR	Cognitive deficits
45	Brown *et al.*[6] 2020	IIIB	5	NR 24–54 Y	1 F, 4 M	Left posterior Mediobasal temporal region gliomas	5 L	NR	Transcorticosubcortical approach	Middle temporal gyrus	Parallel to gyrus	NR	NR	NR	Nil
46	Li *et al.*[26] 2020	IIIB	253	42 Y 19–70 Y	137 M, 116 F	Insular gliomas	119 L, 134 R	Supine.	Transcortical approach	Inferior frontal gyrus/superior temporal gyrus	Parallel to gyrus	NR	retractor	NR	Tumor progression occurred in 98 (38.7%) of the patients And 71 (28.1%) patients died of their disease. One died due to and One patient died of brain trauma.
47	Vivas *et al.*[51] 2020	IIIB	13	NR 13–62 Y	8 M, 5 F	Glioneuronal tumors	NR	Supine position	Transcortical approach	Inferior temporal Gyrus.	Parallel to gyrus	NR	NR	NR	Seizures in 13 patients (92%)
48	Elkallaf *et al.*[10] 2021	IIIB	20	16.1 Y 1–45 Y	9 M, 11 F	Intraventricular tumor	NR	NR	Transcortical approach	Middle frontal, temporal gyri/superior parietal gyrus/ occipitotemporal gyrus/ supramarginal/occipital pole	Direction not specified	NR	NR	NR	All 20 cases showed a Glasgow outcome score of 5 at 3, 6, and 9 months, postoperatively, along with no recorded mortalities.
49	Cao *et al.*[7] 2021	IIIB	43	33.7 Y 12–7 Y	26 M, 17 F	Central Neurocytoma	NR	NR	Transcortical	Lobe/gyrus not specified	Direction not specified	NR	NR	NR	KPS score of 24 (55.8%) patients remained unchanged, 15 (34.9%) patients declined, And 4 (9.3%) patients improved.
50	Sharifi *et al.*[45] 2021	IIIB	11	31 Y 17–57 Y	NR	Amygdala lesion	9 L, 2R	Supine	Trans-middle temporal gyrus trans-ventricular approach	Middle temporal gyrus	Parallel to gyrus	NR	NR	NR	Recurrence with CSF dissemination, Death Memory loss, and Mood disorders.

D: Day, F: Female, KPS: Karnofsky performance status, L: Left, M: Male, NR: Not recorded, R: Right, PostOp: postoperative, Y: Year, AVM: Arteriovenous malformation

Table 2: A summary of the demographics and clinical characteristics.

Characteristics	Value
Cohort size (*n*)	2,604
Demographics	
Median and Range of the age	31 years (5 days–80 years)
Gender	2,269
Male	1,311 (57.78%)
Female	958 (42.22%)
Primary pathology (*n*=2,797)	**No. (%)**
Tumors	1,695 (60.60)
Site	1012 (59.70)
Intraventricular tumors	643 (63.53)
Lateral ventricle	453 (70.45)
Frontal horn, foramen of Monro	163 (35.98)
Body of the ventricle	52 (11.47)
Temporal horn	48 (10.59)
Atrium	27 (5.96)
Trigone	24 (5.29)
Cella media	18 (3.97)
Septum pellucidum	14 (3.09)
Occipital horn	12 (2.64)
Not classified	95 (20.97)
3rd ventricle	149 (23.17)
Not classified	41 (6.37)
Parenchymal	369 (36.46)
Temporal lobe tumors	351 (95.128)
Temporomediobasal tumors	246 (70.08)
Non-classified	105 (29.91)
Thalamic tumors	18 (4.78)
Thalamopeduncular tumors	10 (55.55)
Not classified	8 (44.44)
Type	683 (40.29)
Gliomas	597 (87.40)
Central neurocytoma	73 (4.61)
Glioneuronal tumors	13 (0.82)
Epilepsy	472 (16.87)
Mesial temporal lobe	322 (68.22)
Bitemporal	150 (31.78)
Intracerebral hematoma	335 (11.97)
Basal ganglia	294 (87.76)
Others	41 (12.23)
AVMs	229 (8.18)
Lobar	146 (63.75)
Temporal	88 (60.27)
Basal ganglia, thalamus, and insula	52 (35.61)
Posterior hippocampus	6 (4.10)
Paraventricular and intraventricular	83 (36.24)
Paratrigonal (Medial)	48 (57.83)
Trigonal	26 (31.32)
Others	9 (4.366)
Cavernomas	45 (1.60)
Supratentorial	28 (62.22)
Paracentral	17 (37.77)
Intraventricular cysticercosis	21 (0.75)
Laterality (*n*=1,237)	
Left	707 (57.15)
Right	530 (42.84)
Surgical position (*n*=723)	
Supine	694 (95.99)
Lateral	27 (3.73)
Prone	1 (0.14)
Semi-sitting	1 (0.14)

AVMs: arteriovenous malformations

included articles reported 952 approaches; the transcortical transtemporal approach is the most commonly identifiable cortical approach (70.48%), followed by transcortical transfrontal (16.80%). Among the identifiable transcortical-transtemporal approaches, the most common was transcortical amygdalohippocampectomy (28.76%), followed by (8.19%) of identified transcortical-transtemporal approaches for other non-epileptic indications. Most of the transcortical-transtemporal approaches were not specified (54.99%), and a significant percentage of not specified transcortical trans frontal approaches were also reported (62.50%).

The most frequently accessed brain lobe was the temporal lobe (55.68%), and the most common location for cortical incision was through the middle temporal gyrus (71.09% of the transcortical-transtemporal cases). The second most common lobe accessed was the frontal lobe (24.66%) [Figure 3].

The anatomy of the incision was mainly parallel to gyri (62.1%) or unspecified (37.9%). The cortical incision length was primarily 3 cm (42.63%) and commonly located in the temporal lobe. The median length of the cortical incisions was 2 cm and ranged from 1 to 3 cm. Intraoperative image guiding systems, including diffusion tensor imaging and fiber tractography, were used in 46.01% of surgeries. The postoperative course was mainly reported as outcome measures, including good (55.52%), poor (28.38%), and death (14.62%). Among patients with poor outcomes, specific complications were recorded in 201 transcortical cases. Neurocognitive defects were the most common reported complication (27.23%), followed by hemiparesis (21.89%), seizures (19.8%), quadrantanopia (6.93%), and subdural hematoma (3.96%).

DISCUSSION

Transcortical approaches have been critical corridors for targeting intracranial lesions for many decades, but detailed information on these approaches remains scarce in the neurosurgical literature. In our review, we found that brain tumors, particularly gliomas, were the most frequent lesions accessed through these approaches, with the transcortical-transtemporal approach emerging as the most commonly reported route.

Table 3: Summary of the management strategies and outcomes.

Characteristics	Values
Anatomy of incision (*n*=1665)	**No. (%)**
Approaches (*n*=952)	**No. (%)**
Transcortical-Transtemporal	671 (70.48)
Transcortical Amygdalohippocampectomy	193 (28.76)
Transcortical-Transtemporal-Transventricular	55 (8.19)
Transcortical Peri-insular hemispherotomy	45 (6.70)
Transsulcal-Transoccipitotemporal sulcus	9 (1.34)
Not specified Transcortical-Transtemporal	369 (54.99)
Transcortical-Transfrontal	160 (16.80)
Transfrontal-Transventricular	60 (37.50)
Not specified Transcortical-Transfrontal	100 (62.50)
Transcortical Equatorial	50 (5.25)
Transcortical-transcingulate	27 (2.83)
Transcortical-transparietal	22 (2.31)
Others	22 (2.31)
Brain Lobe access (*n*=677)	**No. (%)**
Temporal	377 (55.68)
Middle temporal gyrus	268 (71.09)
Inferior temporal sulcus	20 (5.31)
Superior temporal sulcus	2 (0.53)
NR	87 (23.08)
Frontal	176 (24.66)
Middle frontal gyrus	94 (53.41)
Precentral sulcus	6 (3.41)
NR	76 (43.18)
Parietal	71 (10.48)
Superior parietal lobule	66 (92)
Postcentral sulcus	5 (8)
Cingulate gyrus	33 (4.87)
Parallel to gyri	1034 (62.1)
Unspecified	631 (37.9)
Length of incision (*n*=387)	**No. (%)**
Temporal	
3 cm	165 (42.63)
2 cm	110 (28.42)
1 cm	97 (25.06)
1.5 cm	11 (2.84)
Parietal	
2 cm	4 (1.03)
Median and range	2 cm (1–3 cm)
Intraoperative tools (*n*=1267)	**No. (%)**
Image guidance system	583 (46.01)
Microscope	307 (24.23)
Retractor	253 (19.97)
Intraoperative stimulation mapping	61 (4.81)
Intraoperative ultrasound	36 (2.84)
Electrophysiological monitoring	27 (2.13)
Duration of surgery (*n*=125)	**No. (%)**
2–36 h	55 (44)
2–30 h	51 (40.8)
4.14±0.59 h	19 (15.2)
Post op. course (*n*=1057)	**No. (%)**
Good	584 (55.52)
Poor	300 (28.38)
Death	144 (14.62)
Unchanged	29 (2.74)
Complications (*n*=201)	**No. (%)**
Neurocognitive defects	55 (27.23)
Hemiparesis	44 (21.89)
Seizure	40 (19.8)
Quadrantanopia	14 (6.93)
Subdural hematoma	8 (3.96)
Diencephalic injury	6 (2.97)
Severe brain edema	5 (2.47)
Aphasia	4 (1.98)
Others	25 (12.37)

NR: Not recorded.

Navigating intra-axial lesions, the cortex, the underlying tract fibers, and the region's eloquence deserve consideration. Evaluating the functional significance of both the cortical and subcortical zones, along with the objectives of the surgical approach, is critical for selecting the most suitable transcortical pathway. Regarding the location of the cortical access incision within the lobe, the temporal and frontal lobes seem to have advantages related to relatively less eloquent areas to be traversed. In this review, the primarily accessed lobe was the temporal lobe (55.68%), with the middle temporal gyrus being the most accessed area (71%). Ali *et al*.[1] managed 211 patients with refractory focal onset mesial temporal epilepsy by transcortical selective amygdalohippocampectomy (SAH). The authors reported that, when performing transcortical SAH, it is crucial to access the temporal horn of the lateral ventricle through a safe passageway and expose the mesial temporal structures for resection. In general, a 3 cm × 3 cm craniotomy suffices, and the surgical approach exposes the lateral temporal gyri. Familiarity with gyrus patterns aids in navigation during the procedure to select the cortical incision through the middle temporal gyrus.[1] Comprehending the complex, surgery-related anatomical aspects of this approach is vital for ensuring successful results when addressing medically intractable epilepsy.

The frontal lobe was the second most frequent lobe (24.66%), mostly at the level of the middle frontal gyrus (53.41%). Lesions within these areas seem to be versatile, either intraparenchymal or ventricular. Other studies described more lobes to be accessed, including the parietal lobe (10.48%) and the cingulate gyrus (4.87%).

As regards the approach' nomenclature, those comprised a variety of transcortical corridors classified according to the

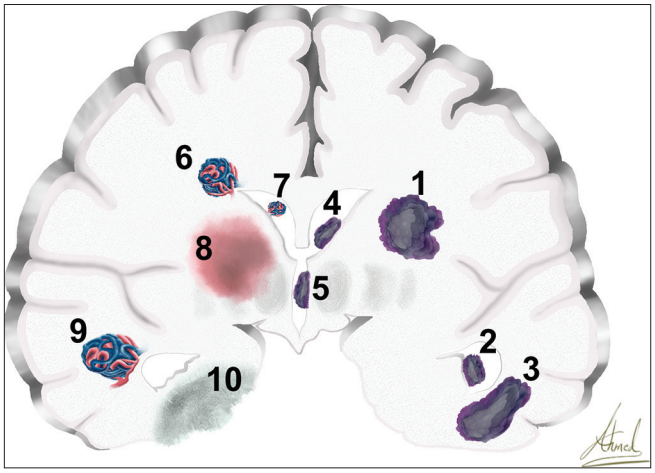

Figure 2: Coronal section of the cerebrum shows different pathologies. (1) glioma, (2) temporal horn of lateral ventricular tumor, (3) temporal lobe tumor, (4) frontal horn of lateral ventricular tumor, (5) third ventricular tumor, (6) paraventricular arteriovenous malformations (AVM), (7) intraventricular AVM, (8) thalamic intracerebral hemorrhage, (9) temporal lobe AVM, and (10) mesial temporal epilepsy.

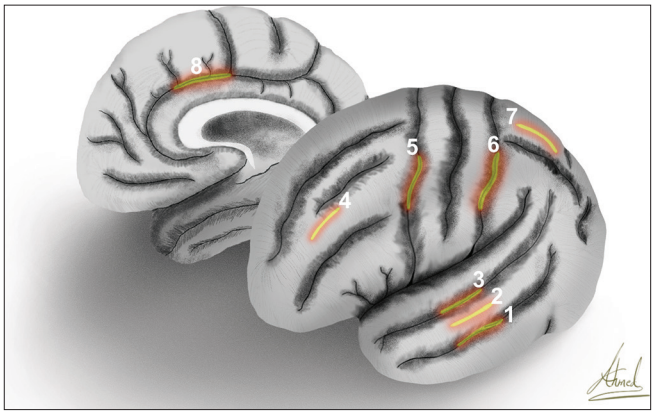

Figure 3: Artistic depiction exhibits the lateral surface of the left hemisphere and medial surface of the right hemisphere with the marking of the cortical incisions of (1) inferior temporal sulcus, (2) middle temporal gyrus, (3) superior temporal sulcus, (4) middle frontal gyrus, (5) precentral sulcus, (6) postcentral sulcus, (7) superior parietal lobule, and (8) cingulate gyrus.

anatomical location and the target. The transtemporal are the most commonly reported approaches (70.48%) in our review, followed by transfrontal approaches (16.8%). The transtemporal pathway includes three main categories: proper transcortical-transtemporal, transcortical amygdalohippocampectomy, and transtemporal trans ventricular. Those approaches are the highways that can be steered in trajectory according to the aimed location of the lesion.

Mazher *et al*.[28] performed an open transventricular approach in 33 patients with intraventricular lesions. This patient population encompassed a diverse array of targeted tumor pathologies, including colloid cysts, giant cell astrocytomas, subependymomas, and choroid plexus papillomas. Among the 33 cases examined, 73% (24 patients) achieved a good outcome, while 24% (8 patients) reported a fair outcome, and a single patient encountered a poor outcome.

The pathologies treated with transcortical approaches have brain tumors representing the majority at 60.6% of the total intracranial pathologies. Those brain tumors are intraventricular more than intraparenchymal locations. The lateral ventricle represents the most involved ventricular cavity with approaching lesions within the frontal horn and the region around the foramen of Monro. Vascular lesions like AVMs comprised 8.18% of reported cases. Those AVMs that were operated using transcortical approaches include either parenchymal AVMs in the temporal lobe, followed by basal ganglia, thalamus, and insula, or periventricular/intraventricular AVMs mostly related to the atrium of the lateral ventricle.

Given the necessity for direct cortical incisions, transcortical approaches, notably for intra-axial lesions, may be linked to a heightened risk of complications. Conversely, the interhemispheric approach appears to be more suitable for pure cingulate gliomas, as evidenced by the successful complete tumor resection in nine out of ten patients, as reported by von Lehe and Schramm [52]. Transcortical approaches were preferred for instances of supra cingulate corridor, especially when tumors reached the hemisphere's surface. The functional outcomes, encompassing both temporary and long-lasting deficits, vary among patients and are influenced by factors such as the tumor's location, the degree of resection, and the chosen surgical technique.

Multiple factors, including anatomical orientation, functional eloquence, and the characteristics of the lesion, primarily influence the selection of the specific surgical incision. The chosen technique may also vary depending on lesion-specific pathology, from gliomas to AVMs, ventricular lesions, and infections.[22,52,53] For instance, in glioma surgery, the initial cortical incision has been reported as short as 1 cm, enough for accessing the lesion, followed by internal debulking and inspection of the cavity to confirm complete resection. On the other hand, surgery for deep-seated AVM required a larger cortical incision (2 cm) to ensure adequate exposure and explore the vasculature.[4] The size of the incision needs also to be customized to the pathology. For hydatid cysts, the length of the cortical incision would be around two-thirds of the larger diameter of the intraparenchymal cyst. [24] In this review, the pooled median length of the used cortical incision was 2 cm (ranging from 1 to 3 cm), with the temporal lobe being the most frequent lobe incised.

Limitations

The selection of sulci, gyri, and subgyral incisions across the different studies may have been influenced by the surgeon's

expertise and the specific features of the lesion, thus needing to be addressed based on each case. The direction of the identifiable gyral incisions in the studies was mainly parallel to the gyri, and there is limited additional data to perform a comparison. In the included studies, there is a lack of data on this subject, as most studies have concentrated on the direction of the approach rather than the intricacies of the cortical access point description.

CONCLUSION

Transcortical approaches are essential techniques using specific cortical incisions as entry points. Intra-axial and intraventricular brain tumors, particularly gliomas, were the most frequently targeted pathologies. The selection of an incision length and location and surgical corridor depends on the lesion's anatomical and functional features and specific pathology. It is critical to understand the intricacies of these approaches and individualize the technique based on each patient's unique anatomy and peculiar lesion characteristics.

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.

Financial support and sponsorship

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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SUPPLEMENTARY FILE 1

Joanna Briggs Institute Checklist for Case Series – Criteria.

1. Were there clear criteria for inclusion in the case series?
2. Was the condition measured in a standard, reliable way for all participants included in the case series?
3. Were valid methods used for identification of the condition for all participants included in the case series?
4. Did the case series have consecutive inclusion of participants?
5. Did the case series have complete inclusion of participants?
6. Was there clear reporting of the demographics of the participants in the study?
7. Was there clear reporting of clinical information of the participants?
8. Were the outcomes or follow up results of cases clearly reported?
9. Was there clear reporting of the presenting site (s)/clinic (s) demographic information?
10. Was statistical analysis appropriate?

Responses Options: Yes, No, Unclear, Not Applicable (NA)
Quality Rating: Poor 0–3; Fair 4–7; Good 8–10

Bias assessment of the included studies.

Study	1	2	3	4	5	6	7	8	9	10	Rating
Ignacio *et al.* 1983	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	9-Good
Carmel, 1985	No	Unclear	No	No	No	No	No	Yes	Yes	No	2-Poor
Hoi, 1985	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Unclear	7-Fair
Waga, 1986	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Unclear	8-Good
Schijman *et al.* 1990	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10-Good
Pendl *et al.* 1992	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Unclear	7-Fair
Barrow and Dawson, 1994	No	Unclear	Unclear	Yes	No	Yes	Yes	Yes	Unclear	Unclear	4-Fair
Roszkowski *et al.* 1995	Yes	Yes	Yes	Yes	No	Unclear	Yes	Yes	Yes	Yes	8-Good
Villemure and Mascott, 1995	Unclear	Yes	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	Unclear	4-Fair
Kikuchi *et al.* 1997	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes	7-Fair
Gökalp *et al.* 1998	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10-Good
Nair *et al.* 1999	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	7-Fair
Olivier, 2000	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	0-Poor
Shimizu and Maehara, 2000	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	Unclear	Yes	Unclear	6-Fair
Ellenbogen *et al.* 2001	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8-Good
Miyagi *et al.* 2002	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes	7-Fair
Ozek and Ture, 2002	Unclear	No	No	Unclear	Unclear	No	Unclear	Yes	Yes	Unclear	2-Good
Asgari *et al.* 2003	Yes	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	No	Yes	7-Fair
Helmstaedter *et al.* 2004	Unclear	Unclear	Unclear	No	No	No	Unclear	Yes	Yes	Yes	3-Poor
Lutz *et al.* 2004	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9-Good
Schaller *et al.* 2004	Yes	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	8-Good
Mittal *et al.* 2005	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	10-Good
Schramm, 2008	Yes	Yes	Yes	Yes	No	Yes	Yes	Unclear	Yes	Yes	8-Good
Seçer *et al.* 2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	9-Good
von Lehe and Schramm, 2009	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8-Good
Zhou *et al.* 2008	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8-Good
Doglioglu *et al.* 2010	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	NR	6-Fair
Juretschke *et al.* 2010	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Thudium *et al.* 2010	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	NR	6-Fair
Broadway *et al.* 2011	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Shi *et al.* 2011	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	9-Good
Park *et al.* 2012	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	NR	7-Fair
Gabarrós Canals *et al.* 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Mazher *et al.* 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Potts *et al.* 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	9-Good
Wang *et al.* 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	8-Good
Zhang *et al.* 2013	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	9-Good
Faust *et al.* 2014	Yes	Yes	No	No	Yes	Yes	Yes	No	No	NR	5-Fair
Hussain *et al.* 2014	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	NR	7-Fair
Gao *et al.* 2016	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	9-Good
Morshed *et al.* 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	9-Good
Zhu *et al.* 2017	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8-Good
Hameed *et al.* 2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8-Good
He *et al.* 2019	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	8-Good
Brown *et al.* 2020	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	6-Fair
Li *et al.* 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	8-Good
Vivas *et al.* 2020	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Elkallaf *et al.* 2021	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	NR	8-Good
Cao *et al.* 2021	No	No	Yes	No	Yes	Yes	Yes	Yes	No	NR	5-Fair
Sharifi *et al.* 2021	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	NR	6-Fair