American Epilepsy Society/American Clinical Neurophysiology Society Intraoperative Electrocorticography Clinical Practice Guideline

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Funding Statement: The systematic review and development of this clinical guideline was funded by the American Epilepsy Society.

Disclosures
The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Demos Medical Publishing (AMH), EISAI, Inc. (AMH), EpiMinder (WOT), Jazz Pharmaceuticals (AMH, SUS), LivaNova USA, Inc. (AMH), Marinus Pharmaceuticals (AMH), Merck (AMH), Neurelis, Inc. (JP, WOT), PranaQ (AMH), SK Life Sciences (SUS), Springer Publishers (AMH), Synergy In-Home diagnostics (SUS), Synergy Integrated Medical Solutions LLC (WOT), UCB, Inc. (AMH, RS, SUS, WOT), UniQURE (AMH), Wolters Kluwer (AMH), Xenon (WOT). The other authors declared no

potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgements: Becky Skidmore, MLS; Lauren Orciuoli, MBA, MPH, American Epilepsy Society

Abbreviations: AES-American Epilepsy Society; ACNS-American Clinical Neurophysiology Society; CPG-Clinical Practice Guideline; DCS- Direct Electrical Cortical Stimulation; DRE-Drug Resistant Epilepsy; EEG-Electroencephalography; FBM-Functional Brain Mapping; GPS-Good Practice Statement; GRADE-Grading of Recommendations Assessment, Development, and Evaluation; HFO- High Frequency Oscillations; IED- Interictal Epileptiform Discharges; ILAE-International League Against Epilepsy; ioECoG-Intraoperative electrocorticography ; RNS- Responsive Neurostimulation; RCT-Randomized Controlled Trial; sEEG- Stereoelectroencephalography; SUDEP- Sudden Unexpected Death in Epilepsy; TLE-Temporal lobe epilepsy

Keywords: Intraoperative Electrocorticogram, ioECoG, seizure outcome, brain surgery, clinical practice guideline, electrocorticography, ECoG

Abstract

Intraoperative electrocorticography (ioECoG) has been used for nearly 100 years as an adjunct procedure during resective brain surgeries for the management of drug-resistant epilepsy. With advances in presurgical capabilities, including reliance on prolonged extra-operative intracranial recording for approximation of the epileptogenic zone, utilization of ioECoG has become less consistent. This clinical practice guideline (CPG) from the American Epilepsy Society (AES) and the American Clinical Neurophysiology Society (ACNS) provides evidence-based recommendations for the use of ioECoG as an adjunct to resective brain surgeries. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology was used to complete a comprehensive literature review and the subsequent recommendation of decision-making process.

Following the GRADE process, the following recommendations were developed:

1. We suggest using ioECoG in patients undergoing resective brain surgery (conditional recommendation, very low certainty of evidence).
2. We suggest using ioECoG findings to determine complete versus incomplete resection in patients undergoing resective brain surgery (conditional recommendation, very low certainty of evidence).
3. Good Practice Statement: For patients undergoing ioECoG recording, instituting pre- and post-surgical psychological and psychiatric assessments should be considered.

Introduction

Intraoperative electrocorticography (ioECoG) was pioneered in 1929 and became an aid in the surgical treatment of drug-resistant focal epilepsy. Decades later, the main goal of ioECoG remains the same: to better estimate the boundaries of the epileptogenic zone during resective surgery and guide the extent of resection. For patients with drug resistant epilepsy, ioECoG has been primarily used to detect interictal epileptiform discharges (IEDs) directly from the brain surface during the resection based on evidence that IEDs are markers of the epileptogenic zone.[1] However, the duration of ioECoG is rarely sufficient to record spontaneous seizures. Over the past 30 years, the ongoing utility of ioECoG has been controversial following increased usage of prolonged intracranial EEG recording with stereo- or subdural electrodes (i.e. "phase II" pre-surgical monitoring) aiming to improve precision in cortical distribution of spikes and localizing seizure onset zone to guide surgical resection.[2] Today, some epilepsy centers continue to employ ioECoG during epilepsy surgery, while other centers have reduced its utilization to only selected cases or abandoned the procedure entirely, limiting its application solely for direct electrical cortical stimulation (DCS) during functional brain mapping (FBM).[3] The purpose of this clinical practice guideline is to systematically assess the available evidence evaluating efficacy of ioECoG during resective brain surgeries.

The PICO (population, intervention, comparator, outcomes) questions for this guideline formulated by a panel of experts and modified after public comments were:

1. Should ioECoG, compared to no ioECoG, be used for patients undergoing resective brain surgery?
2. Do the outcomes of complete versus incomplete resection, as defined by abnormal ioECoG findings, differ?
3. Do psychological and psychiatric outcomes differ among patients undergoing awake vs. asleep ioECoG recording?

Rationale

Achieving seizure freedom is the ultimate goal of resective brain surgery. However, about 27.5% of patients continue having seizures after the operation.[4] The question of whether ioECoG can assist in delineation of epileptogenic zone and improve outcomes remains open.[5]

Achieving postoperative seizure freedom in patients with non-lesional drug resistant focal epilepsies continues to present a particular challenge. It is reported that the postsurgical seizure freedom remains significantly lower in non-lesional cases.[6-9] In such instances, reliance on neurophysiological data for the delineation of the epileptic network may be even greater. In lateral temporal lobe resection, for example, ioECoG is used to consider additional resection of mesial temporal lobe structures. The extra-temporal drug-resistant epilepsies (DRE) constitute a further challenge. The odds of seizure freedom after surgery for extratemporal lobe epilepsy are lower compared to temporal lobe epilepsy (TLE).[10]

Tumor-related epilepsies demonstrate a unique relationship between the seizure onset zone and the lesion itself. Removal of the peri-tumoral epileptogenic zone may improve seizure-related outcomes.[11] The utility of ioECoG in determining the extent of the peri-lesional tissue resection is based on identification of the irritative zone and safe resection of the electrographically abnormal non-eloquent brain area.[12]

Intraoperative ECoG is performed prior to the start of the resection and continued until surgery is complete. This approach provides neurophysiological basis for the demarcation of the potentially resectable cortex and prediction of seizure freedom, particularly if not all the tissue generating epileptiform activity is resected.[13-15] The main data sourced during ioECoG consists of slowing, paucity of faster frequencies, presence of epileptiform potentials, and, only rarely, seizures. The predictive value of interictal epileptiform activity in seizure outcomes has been attributed to spike frequency, morphology, and spatial distribution. However, controversy remains if complete surgical resection of the electrographically abnormal cortex identified by ioECoG results in improved seizure outcomes.[16]

Based on the evolving clinical practice in the pre-surgical evaluation for epilepsy surgery, the American Epilepsy Society (AES) and the American Clinical Neurophysiology Society (ACNS) leadership deemed it important to evaluate scientific evidence on the utility, risks and benefits of ioECoG. Therefore, AES and ACNS convened an expert panel to design and perform a systematic review of the topic, then use the current evidence to formulate this guideline.

By Work Group consensus, this guideline focuses on traditional clinical use of ioECoG. Although some epilepsy centers use high frequency oscillations (HFOs) to further guide resection margins, the relationship between HFOs and postoperative seizure outcomes is still considered investigational and is beyond the scope of this guideline.[17] While some Work Group members did express differing opinions, the decision to exclude HFOs reflected two main considerations. First, robust data is needed for a rapidly evolving technology whose literature remains limited and unsettled. Second, not all centers have the equipment or expertise to perform highly sophisticated recording analysis and interpretation on-site in real time. Consequently, potential misuse remains a concern until additional experience and expanded capabilities are more widely available. HFOs recorded during ioECoG may be addressed in a future update of this guideline, or in a separate guideline, once sufficient evidence becomes available.

Intraoperative ECoG as a procedure requires advanced planning and coordination of the multidisciplinary team, including neurosurgeon(s), epileptologist(s), clinical neurophysiologist(s), anesthesiologist(s), technologists, and, in some centers, neuropsychologist(s). Possible implications and complications of ioECoG include increased operating time, increased bleeding, and infection. If electrical stimulation is used for brain mapping, intraoperative seizures may occur. This guideline aims to

determine if those complications are uniquely associated with ioECoG and if those complications impact utilization of ioECoG during resection.

In recent years, there has been a considerable paradigm shift in how goals of patient care and delivery are defined. Inputs from patients and their families and caregivers, including active participation in decision making, setting expectations, and detailed education in preparation for surgery, are now essential in pre-surgical planning. One aim of this guideline is therefore to identify pertinent evidence of the impact of ioECoG on postoperative quality of life.

Guideline Recommendations Summary

1. The panel suggests using ioECoG vs. no ioECoG in patients undergoing resective brain surgery (conditional recommendation).
2. The panel suggests using ioECoG findings to determine complete versus incomplete resection in patients undergoing resective brain surgery (conditional recommendation).
3. Good Practice Statement: For patients undergoing ioECoG recording, instituting pre- and post-surgical psychological and psychiatric assessments should be considered. (Table 1)

Treatment Intervention and Comparator	Recommendation (please see Summary of Evidence for detailed evidence review of each intervention)
I. Intraoperative Electrocorticography in Patients Undergoing Resective Brain Surgery	The AES/ACNS guideline panel suggests using ioECoG vs. no ioECoG in patients undergoing resective brain surgery *Remarks for Recommendation I:* – Use of ioECoG should be based on individual patient situation or requirements of acquiring additional neurophysiological data with the information already available – Use of ioECoG is based on training background and expertise of the team involved in ioECoG – Prolonging surgery may increase the risk of infection, although evidence is lacking – A pre-operative intracranial evaluation may reduce the need for ioECoG, although evidence is lacking (**Conditional** recommendation, **Very Low** certainty of evidence).

II. Complete Versus Incomplete Resection as Defined by Abnormal ioECoG Findings	The AES/ACNS panel suggests using ioECoG findings to determine complete versus incomplete resection in patients undergoing resective brain surgery. *Remarks for Recommendation II:* – While respecting safety boundaries and preserving eloquent cortex (**Conditional** recommendation, **Very Low** certainty of evidence)
III. Psychological and Psychiatric Outcomes among Patients Undergoing Awake versus Asleep ioECoG Recording	Good Practice Statement: For patients undergoing ioECoG recording, instituting pre- and post-surgical psychological and psychiatric assessments should be considered.

Table I: Summary of recommendations

Methods

Overview of Guideline Development Process

The guideline development process was guided by AES and ACNS policies and procedures and overseen by the AES Guidelines and Assessment Committee.[18] A panel of topic experts developed this clinical practice guideline based on systematic reviews of treatment effectiveness, comparative effectiveness, and harms following GRADE methodology. The collaborative AES/ACNS guideline panel included 14 epileptologists / clinical neurophysiologists (12 adults, 2 pediatrics), and one patient representative. Four of these panelists represented ACNS, and 10 represented AES. The patient representative panelist did not represent an organization. Panelists' conflicts of interest (COI) disclosures were obtained, reviewed, and managed at the start of the project and regularly updated throughout its development (Supplement 1). Data analysis was performed by the Cochrane Response group using the GRADE methodology in assessing the evidence and developing the guideline recommendations.[19] This clinical practice guideline was developed with financial support from the AES.

Formulating Specific Clinical Questions and Determining Outcomes of Interest

The panel selected three PICO questions to evaluate the clinical utility of ioECoG and its implications for surgical and patient-centered outcomes. Collectively, these questions were designed to assess not only seizure outcomes but also the broader benefits, harms, quality-of-life effects, and patient-centered considerations relevant to informed decision-making pertaining to ioECoG use during resective brain surgery. This guideline aimed to assess available evidence published between January 1, 1992, and May 8, 2024.

While assessing the best available evidence for each PICO question, the panel developed a specific population (P), intervention (I), comparator (C), and the corresponding patient-important outcomes (O) in alignment with current clinical practice and accepted standards.

The outcomes prioritized for PICO 1 and 2 were post-operative seizures; all-cause mortality, including sudden unexpected death in epilepsy (SUDEP); serious adverse effects (bleeding or intracranial hemorrhage, infection, unexpected permanent functional deficits, functional outcomes, neurological or visual field deficits, and complications potentially related to ioECoG); quality of life; intraoperative seizures; patient satisfaction; medical or medication-related adverse events; and post-operative depression or anxiety.

Postoperative seizure outcomes were classified as Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; and dichotomous "seizure free vs. not" at four different time points after operation (≤ 2 weeks, >2 weeks to ≤ 6 months, >6 months to ≤1 year, and >1 year). In addition, Engel I-II vs III-IV, ILAE 1-3 vs 4-6 and dichotomous “seizure free vs. not” were analyzed and reported. The panel also agreed on a 5% clinically important difference (i.e. the threshold for meaningful patient benefit) for the outcome of post-operative seizures.

The outcomes prioritized for PICO 3 were post-operative seizure outcomes; quality of life; intraoperative seizures; pre-operative hesitation to undergo surgery with awake ioECoG; intraoperative patient discomfort; post-operative patient satisfaction; post-operative psychosis; medical or medication-related adverse events; post-operative pain; and post-operative depression or anxiety.

Evidence Review and Development of Recommendations

These recommendations are informed by rigorous, high-quality systematic reviews for each PICO question. The literature search was performed using the Cochrane Central Register of Controlled Trials (CENTRAL) via EBM Reviews (OVID), MEDLINE (OVID), and Embase (OVID). Searches through CENTRAL and MEDLINE were inclusive of the earliest possible search date to April 4, 2024. Embase was searched from January 1, 1992, through May 8, 2024. The panel completed dual independent literature screening. The methods team completed data extraction and risk of bias assessments of included studies. The methods team assessed the certainty of evidence and developed concordant recommendations using the GRADE evidence-to-decision framework (Supplement 2).

PICO 1 evaluated ioECoG as a distinct intraoperative procedure during resective brain surgery, irrespective of pre-resection intracranial monitoring use, to determine whether its utilization is associated with improved outcomes. Recognizing that use of ioECoG may vary by epilepsy etiology, particularly among tumor-related, lesion-specific, and non-lesional epilepsies, the panel considered subgroup analyses by etiology when supported by available evidence. The panel also evaluated outcomes beyond seizure freedom, including mortality, adverse events, quality of life, patient satisfaction, and psychological outcomes.

PICO 2 examined whether outcomes differ following complete versus incomplete resection of regions demonstrating abnormal ioECoG findings, reflecting the potential role of ioECoG in guiding the extent of resection. Because the clinical significance of residual interictal epileptiform discharges (IEDs) remains uncertain and because resection may be constrained by eloquent cortex and other anatomic considerations, the panel used definitions of complete and incomplete resection as reported in the literature rather than further classifying IED patterns. Emerging biomarkers such as infra-slow activity and high-frequency oscillations were considered outside the scope of the guideline.

PICO 3 evaluated psychological and psychiatric outcomes associated with awake versus asleep surgery with ioECoG, recognizing that experiences during awake functional mapping, intraoperative discomfort, and the potential for stimulation-induced seizures may influence patients' treatment choices. Collectively, these questions were designed to assess not only seizure outcomes but also the broader benefits, harms, quality-of-life effects, and patient-centered considerations relevant to informed decision-making regarding ioECoG use during resection.

A total of 12,593 studies were originally screened (12,453 from databases, 140 from handsearching systematic reviews). Of these, 887 were selected for full-text review. A total of 821 studies were excluded. The final systematic review included 59 studies (reported in 66 records) (Figure 1). The methods team integrated the included studies into the GRADE evidence profiles, further developing Evidence-to-Decision tables for each PICO question. The Evidence-to-Decision tables provide the effect estimate and the associated certainty of evidence for each outcome of interest, graded from high level of certainty to moderate, low and very low for the following reasons: limitations in study design or execution (risk of bias), inconsistency of results, indirectness of evidence, imprecision, or publication bias (Supplement 2). Focusing on benefits and harms of ioECoG in patients undergoing resective brain surgery, the results were summarized as desirable and undesirable effects, along with the overall certainty of evidence and used to facilitate the guideline decision-making process. In addition, contextual factors which included values, resources required and cost effectiveness, equity, acceptability, and feasibility were reviewed.

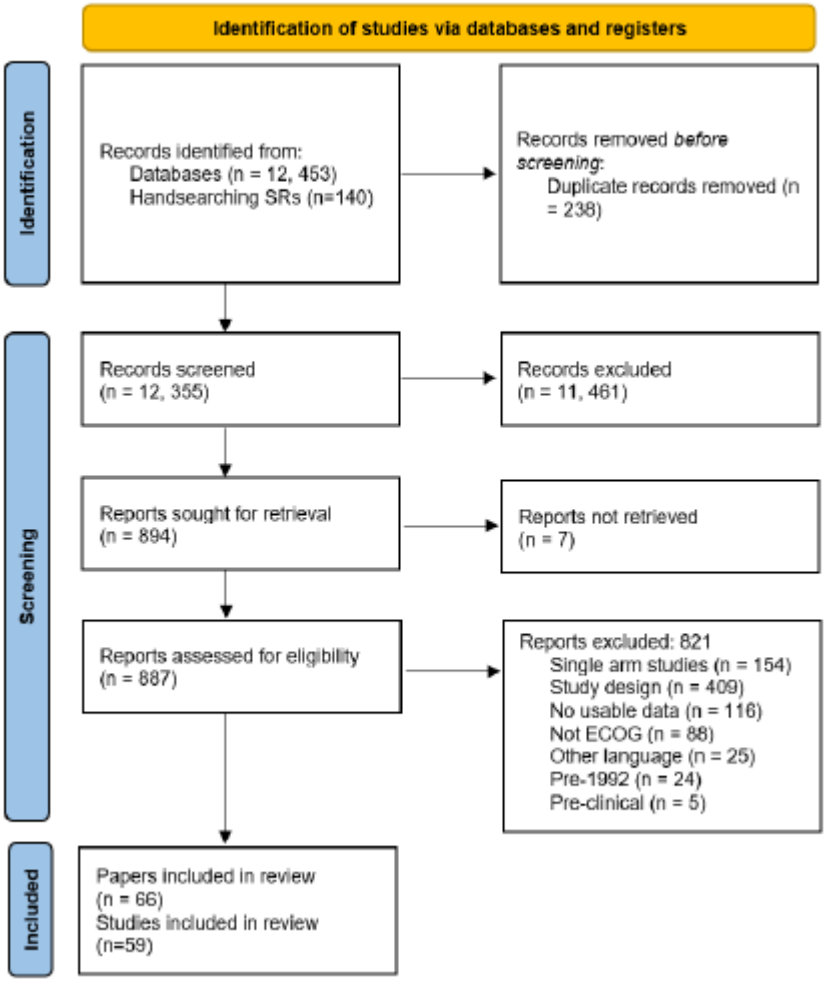


Figure 1. PRISMA flowchart illustrating screening and study selection.

The panel received the relevant evidence profiles and Evidence-to-Decision tables prior to each recommendation development session. The methods team reviewed the profiles and tables with the panel, guiding the panel through evidence analysis in context with each PICO question. This was followed by a robust discussion of the evidence, including benefits and harms. The panel voted on each element of the Evidence-to-Decision table, and votes were recorded (Supplement 2). Recommendations were informed by the evidence presented and informed discussion and were adopted after panel vote and consensus.

Summary of Evidence

Summary of Recommendations Related to Intraoperative Electrocorticography in Patients Undergoing Resective Brain Surgery

Recommendation I: The AES/ACNS guideline panel suggests using ioECoG vs. no ioECoG in patients undergoing resective brain surgery (**Conditional** recommendation, **Very Low** certainty of evidence).

Remarks for Recommendation I:

- Use of ioECoG should be based on individual patient situation or requirements of acquiring additional neurophysiological data with the information already available
- Use of ioECoG is based on training background and expertise of the team involved in ioECoG
- Prolonging surgery may increase the risk of infection, although evidence is lacking
- A pre-operative intracranial evaluation may reduce the need for ioECoG, although evidence is lacking

Summary of Evidence

Post-operative seizures.

Thirty-eight studies (1 RCT, 37 non-randomized studies) reported post-operative seizure outcomes in patients receiving either ioECoG or no ioECoG.[20-57] The outcomes were measured using the Engel Classification (1 RCT, 29 non-randomized studies), ILAE Classification (4 non-randomized studies) or no formal classification method (4 non-randomized studies).

Based on clinical use of the different classification systems, the panel agreed to combine the values for Engel I vs II-IV, Engel IA vs all, ILAE 1-2 vs 3-6 and "Seizure free" at 4 different time points (≤ 2 weeks, >2 weeks to ≤ 6 months, >6 months to ≤1 year, and >1 year). The panel also agreed on a 5% clinically important difference (i.e. the threshold for meaningful patient benefit) for the outcome of post-operative seizures.

One study (n=119) reported post-operative seizure occurrence within the first 2 post-operative weeks.[26] Although the results suggest that the ioECoG group may have a higher risk of seizures compared to the group without ioECoG (53.1% vs 68.6%), the population included patient with Glioblastoma multiforme. Two studies (n=151) reported on post-operative seizures occurring 2 weeks to 6 months after surgery and found little to no difference in the risk of seizures between the two groups (92.8% vs 92.3%).[45,52] Six non-randomized studies (n=487) reported that the use of ioECoG may result in more people being seizure free at 6 months to 1 year post-operatively (74.4% vs 68.8%),[23,28,34,45,52,55] with 6 more patients out of 100 being seizure-free in the ECoG group. Although probably clinically important, the confidence interval crosses the CID threshold. One RCT (n=42) suggests little to no difference in the risk of post-operative seizures between the two group at more than 1-year follow-up (98.8% vs 94.7%).[20] Results from 30 non-randomized studies (n=1479) report a potential reduction in risk of seizures with ioECoG[4,21,22,24,27,28,31-38,40,41,42-50,52-54,56,57] with 7 more patients out of 100 being seizures free in ECoG group. However, the confidence interval crosses the CID threshold. The overall effect was statistically significant with unadjusted OR 1.43 (95% CI 1.03, 1.99).

The panel also expressed interest in Engel I-II vs III-IV and ILAE 1-3 vs 4-6 based on patient preferences. For post-operative seizures occurring >2 weeks to ≤6 months, 1 non-randomized study (n=116) with very low certainty of evidence reported a no clinically important difference.[45] For post-operative seizures occurring >6 months to ≤1 year, 2 non-randomized studies (n=224) with very low certainty of evidence reported a probably clinically important difference with 11 more patients out of 100 being seizure-free in the ECoG group; however, the confidence interval crosses the CID threshold.[45,55] For post-operative seizures occurring >1 year, 14 non-randomized studies (n=643) with very low certainty of evidence reported a probably clinically important difference with 8 more patients out of 100 being seizure-free in the ECoG group; however, the confidence interval crosses the CID threshold.[20,23,25,26,34,35,37,38,42,43,45,54-56]

Benefits, Harms, and Burden

Mortality

Nine non-randomized studies reported mortality as an outcome in patients receiving ioECoG or no ioECoG.[21,30,31,40,41,50,52,53,57] Only one study reported any deaths, with one death in each arm, both from brain edema.[53] Both patients died in the first week post-surgery. No other deaths were reported in any time frame.

Serious Adverse Events

Seven studies (1 RCT; 6 non-randomized studies) reported serious adverse events as an outcome in patients receiving ioECoG or no ioECoG.[20,40,47,49,50,51, 57] There was no significant difference between the two groups. All serious adverse events were reported in 16 months or longer post-operative period. A total of 15 serious adverse events were reported: stroke (1), hemorrhage (2), cerebral edema (2), extradural hematoma (1), transient hemiparesis (2), and permanent complications of mild aphasia (2), diplopia (1), nystagmus (1), superior quadrantanopia (1), mild hemiparesis (1), and mild memory impairment (1).

Intraoperative Seizures

One non-randomized study of 477 patients with brain tumors reported intra-operative seizures as an outcome.[39] The unadjusted comparison reported intra-operative seizures were more frequent in patients receiving ioECoG compared to those who did not (unadjusted OR 2.11 (95% CI 1.19, 3.73; p=0.01)).

Conclusions and Research Needs for This Recommendation

The panelists agreed that there is likely a clinically important difference for post-operative seizures when ioECoG is used and is mostly dependent on the availability of trained personnel. While evidence regarding cost was lacking, based on practical experience, the panel agreed that ioECoG is a relatively safe procedure that is not associated with significant cost increase. The panel also agreed that the potential benefits of ioECoG use outweigh the risks.

The panel recommends adherence to consistent documentation of the discussion on potential benefits and harms between provider and patient and consideration of individual patient's values; to perform pre- and post-resection mental health evaluation as well as to document as to why ioECoG was offered to the patient and why the patient might have chosen to decline resection, particularly if awake ioECoG was deemed necessary. As technology advances and understanding of the underlying mechanisms of epilepsy grows, reliance on ioECoG may diminish. In the meantime, ioECoG findings should be consistently included in longitudinal post-operative follow up of outcomes. Further RCT studies are needed to improve the certainty of the evidence. Future research projects should investigate if phase 2 intracranial monitoring can effectively replace ioECoG. It is also important to investigate whether data obtained during ioECoG can be used to improve precision of the responsive neurostimulation (RNS) lead placement.

Summary of Recommendations Related to Complete Versus Incomplete Resection as Defined by Abnormal ioECoG Findings

Recommendation II: The AES/ACNS panel suggests using ioECoG findings to determine complete versus incomplete resection in patients undergoing resective brain surgery. (Conditional recommendation, Very Low certainty of evidence).

Remarks for Recommendation II:

- While respecting safety boundaries and preserving eloquent cortex

Summary of Evidence

Post-operative seizures.
Twenty-two non-randomized studies reported post-operative seizure outcomes in patients receiving either complete or incomplete resection, as defined by abnormal ioECoG findings.[9,16,23,34,51,58-74] The outcomes were measured using Engel Classification (10 non-randomized studies), ILAE Classification (5 non-randomized studies) or no formal classification method (7 non-randomized studies).

Three non-randomized studies (n=205) reported post-operative seizures outcomes *between 6 months to less than one year*.[23,34,62] This evidence suggests that complete resection may result in more frequent reports of "seizure freedom" (81.0% vs 56.2%, OR 1.23, 95% CI 0.04 to 42.12).

For post-operative seizures reported *after 1 year of resection,* there were 19 non-randomized studies (n=1295).[9,16,34,51,58,59,60,61,63-65,67-69,70-74] There was a probably clinically important difference, with 23 more patients out of 100 being seizure-free in the complete resection group; however, the confidence interval crossed the clinically important difference threshold. The overall effect was statistically significant with unadjusted OR 2.82 (95% CI 1.36, 5.84).

When compared Engel I-II vs III-IV and ILAE 1-3 vs 4-6 for post-operative seizures occurring >1 year, 18 non-randomized studies (n=1295) with a very low certainty of evidence reported a clinically important difference, with 21 more patients out of 100 being seizure-free in the complete resection group. The overall effect was statistically significant with unadjusted OR 2.60 (95% CI 1.30, 5.19)

Benefits, Harms, and Burdens

Mortality

One non-randomized study (n=46) reported no deaths in either arm for surgical mortality.[61] Two non-randomized studies (n=50) reported no deaths in either arm for postoperative mortality.[69,70]

Serious Adverse Events.
One non-randomized study (n=24) reported no neurological complications at median 30 months of post-operative period in either arm.[71]

Conclusions and Research Needs for this Recommendation

The available evidence, all from non-randomized studies, suggests that complete resection of ioECoG-defined abnormal cortex is associated with postoperative seizure reduction. However, this evidence is of very low certainty, and the panel noted a lack of evidence on unfavorable neurological outcomes and serious adverse events. The panel also noted potential confounding factors in that resection is often left incomplete because abnormal activity extends into proximity of eloquent cortex. This may predict a poorer seizure outcome. It is recommended that in future publications, ioECoG findings and extent of resection are consistently included in longitudinal follow up of outcomes. The panel also noted that randomized controlled trials are needed to improve the certainty of the evidence and to determine whether ioECoG-guided resection improves outcomes.

Summary of Recommendations Related to Psychological and Psychiatric Outcomes among Patients Undergoing Awake versus Asleep ioECoG Recording

Good Practice Statement: For patients undergoing intra-operative ioECoG recording, instituting pre- and post-surgical psychological and psychiatric assessments should be considered.

Three studies were identified to address this question, though the data could not be pooled for meta-analysis due to small sample sizes.[75-77] This lack of evidence prohibited the panel from developing a recommendation for this question; however, the panel agreed that the question is important to address and followed the GRADE Good Practice Statement (GPS) process to develop the statement above.

While numerous studies addressed preoperative psychiatric and cognitive characteristics of patients deemed eligible for ioECoG (often explicitly stated in the inclusion criteria), no studies systematically described characteristics of patients deemed ineligible. Moreover, no studies addressed psychological or psychiatric outcomes following ioECoG. Only 3 non-randomized retrospective studies were found that directly addressed adverse effects unique to ioECoG, aside from the expected risks of seizure recurrence and surgical complications addressed in PICO1 and 2, namely stimulation-induced intraoperative seizures (3).[75-77]

The panel discussed indirect evidence focusing on the acceptability of awake craniotomy for the removal of lesions in or close to eloquent brain areas. All 5 studies (n=156, age range 16-78 years) reported higher survey scores with awake craniotomy than those reported by patients undergoing craniotomy with general anesthesia (p=0.07).[78-82] Two of these studies reported that 80%[79] and 92.3%[81] of patients surveyed were willing to repeat the awake craniotomy procedure if it was necessary.

Future research on ioECoG outcomes should incorporate pre-operative and post-operative psychological and psychiatric assessments in patients undergoing resective surgeries performed with and without ioECoG. Experts in ioECoG recognize that some patients are less likely to tolerate ioECoG during awake craniotomy; thus, future studies should explicitly state the minimum criteria required for patients to be eligible versus deemed ineligible for ioECoG. While a handful of studies were explicit about their preoperative eligibility criteria for who is offered open versus awake surgeries (e.g. cognitive, psychiatric, and language-related requirements), most studies did not address their inclusion criteria clearly; this likely introduced selection bias that was not accounted for given the non-randomized study design. For example, experts may defer ioECoG due to an individual's cognitive limitations (e.g. neurodevelopmental disorder), psychiatric comorbidities (e.g. high anxiety, post-traumatic stress disorder, etc.), or language deficits (e.g. aphasia); thus, patients who are more likely to tolerate particular challenges associated with awake surgical procedure may be overrepresented in the ioECoG group. Since IQ less than 80 is a risk factor for incomplete seizure freedom following resective epilepsy surgery,[83] and these individuals are less likely to be deemed eligible for awake ioECoG, the research may be systematically biased towards a cohort with a higher IQ.

Discussion

Rendering patients seizure-free is the ultimate goal of any therapy. When medications fail to control seizures and patients meet criteria for a surgical approach, the success of resection depends on precision in delineation of epileptogenic zone. ~~Therefore, the efforts of presurgical planning are directed at accurate approximation of this zone.~~ In the 1950s, ioECoG provided the very first opportunity to evaluate electrical cerebral activity recorded directly from the brain surface following a large craniotomy.[2] Absence of natural filters (skin, skull and meninges) not only improved precision in spatial spike resolution but also altered EEG signal morphology and allowed visualization of frequencies and waveforms

that habitually were muffled out and distorted. These discoveries inherently led to more questions. The concept of green and red spikes was developed, and the importance of precise localization of the seizure onset area from the cortex itself was solidified. These discoveries simultaneously highlighted limitations of ioECoG and shifted focus to prolonged intracranial recordings with stereoelectroencephalography (sEEG) or subdural recordings to localize not only interictal epileptiform activity from distant brain regions, but also seizure onset zones, and as a corollary challenged ioECoG for its limitation to deliver these results. These advances were translated into the 2023 Guidelines for Specialized Epilepsy Centers: Report of the National Association of Epilepsy Centers (NAEC) Guideline Panel for all epilepsy centers seeking Level 4 accreditation, requiring capability for 24-hour video EEG recordings with intracranial electrodes.[84]

Despite universal acceptance and reliance on prolonged intracranial recordings in presurgical workup, the role of ioECoG has not been completely negated. In fact, it retained its complementary use during active surgical resections providing information in real time. Specifically, ioECoG allows precise delineation of spike distribution in the exposed brain surface targeted for resection and remains critical for determining the completeness of the resection and related patient outcomes. In addition, ioECoG is applied in conjunction with direct electrical stimulation for functional brain mapping to monitor after-discharges and induced seizures and to maintain safety boundaries of resection aimed at preserving eloquent cortex. The post-resection ioECoG data may serve not only as a prognostic tool in predicting postoperative seizure recurrence but also as a localizer for subsequent RNS electrode placement. Moreover, there will be a subset of patients who may not need or not be able to tolerate prolonged intracranial recordings outside of operating theater. This is especially relevant for patients with tumor-related epilepsy, who are unlikely to undergo invasive intracranial monitoring and for whom ioECoG is therefore expected to remain an important adjunct tool. In such situations, ioECoG value remains indispensable, and preservation of expertise in ioECoG interpretation skills continues to be integral.

The panel recognizes that as presurgical capabilities advance with prolonged intracranial recording, which increasingly informs estimation of the epileptogenic zone, ioECoG may become less essential for this purpose. However, it may remain an indispensable tool in specific patient populations. Future RCTs are needed to improve the certainty of the evidence regarding the value of ioECoG and should include extended follow-up seizure outcomes.

Through documentation of epilepsy etiology is essential to further characterize subgroups of patients who may benefit to a greater degree from ioECoG.

The transformation of healthcare delivery from a paternalistic to a patient centered approach has made shared decision-making the standard approach to treatment choices. Individual patient values and preferences may alter treatment decisions with patients choosing to opt out from procedures due to the potential of experiencing undue distress. This is particularly pertinent to awake ioECoG.[85] For some patients, the stress of being awake during brain surgery and the risk of having an intraoperative seizure may be intolerable, leading them to decline resection. For all patients who are considered for

resective brain procedures, it is essential to have these conversations and to have detailed documentation of the decision-making process for the chosen therapy. For those patients who choose to undergo resection with ioECoG, preoperative and postoperative psychological evaluations are essential to inform future patients of their experiences and to create a foundation for informed discussions.

Deciphering ioECoG-specific complications distinct from those encountered during surgery itself requires meticulous documentation and subsequent review of all events that occurred in the operating room. Such evidence is currently lacking and should be in future studies.

Since resective brain surgeries take place in specialized centers, most with the highest NAEC accreditation, it is essential to ensure healthcare access for patients residing in remote areas. Utilization of telemedicine, providing transportation to and from centers with advanced testing capabilities, developing pre-authorized healthcare packages and creating opportunities to get care in neighboring states should be considered when coordinating health care provision to eliminate physical distance from determinants of treatment choices and to ensure access to comprehensive evaluation and all available treatment options.

Summary

This guideline systematically evaluates the evidence regarding the use of ioECoG as an adjunct procedure during resective brain surgeries for the management of DRE. Based on the available evidence, the use of ioECoG in patients undergoing resective brain surgery and use of ioECoG findings to determine complete versus incomplete resection is suggested. It is noted that the clinical utility of ioECoG may vary according to patient characteristics, presurgical evaluation, available resources, training, experience, and surgical approach.

Recognizing the importance of patient-centered care and the potential psychological effects of surgical procedures, especially awake ioECoG, the panel issued a good practice statement advising consideration of pre- and post-surgical psychological and psychiatric assessments for patients undergoing ioECoG.

Future research needs include RCTs with extended post-operative follow-up, improved documentation of etiology, ioECoG-specific complications, and further investigation of psychological and psychiatric outcomes.

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Systematic review to support the development of AES/ACNS intraoperative electrocorticography (ECoG) guideline

American Epilepsy Society (AES)
American Clinical Neurophysiology Society (ACNS)

Cochrane Response
January 2026

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Glossary

CI: Confidence Interval

ECoG: Intraoperative electrocorticography

EtD: Evidence to Decision

GRADE: Grading of Recommendations, Assessment, Development and Evaluation

ILEA: International League Against Epilepsy

NRS: Non-randomized study

MD: Mean Difference

PICO: Population, Intervention, Comparison, Outcome

PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses

QoL: Quality of life

RCT: Randomised Controlled Trial

RoB 2: Cochrane Risk of Bias Tool

ROBINS-I: Risk Of Bias In Non-randomized Studies - of Interventions

RR: Risk Ratio

SAE: Serious Adverse Events

SMD: Standard Mean Difference

SUDEP: Sudden Unexpected Death in Epilepsy

Scope and objectives

This systematic review was produced to inform the development of American Epilepsy Society (AES) and American Clinical Neurophysiology Society (ACNS) guideline on intraoperative electrocorticography (ECoG), focusing on three PICO questions that were identified through a prioritization exercise.

Methods

We conducted the systematic review, including the full text screening and selection of studies, data extraction and management, assessment of risk of bias, and data analysis, following the guidance in the Cochrane Handbook[1]. The search and abstract screening were undertaken by AES and provided to Cochrane Response. We followed the guidance of the GRADE Handbook[2] for assessing the certainty of the evidence for each outcome. Every stage of the process was documented. We used DistillerSR software for screening and data extraction and RevMan Web for data analysis.

The protocol was registered in PROSPERO, the International prospective register of systematic reviews (https://www.crd.york.ac.uk/PROSPERO/view/CRD420251062036).

Population, Intervention, Comparisons, Outcomes, Study design (PICOS)

See below for detailed PICO questions addressed by this review.

1. **PICO 1: Should intraoperative electrocorticography (ECoG), compared to no intraoperative ECoG, be used for patients undergoing resective brain surgery?**
    - Population(s): All patients undergoing resective brain surgery
    - Intervention(s): Intraoperative ECoG
    - Comparator(s): No intraoperative ECoG
    - Outcome(s): *[In order of Work Group priority/importance rating]*
        - Post-operative seizure outcomes - as reported by any Engel or International League Against Epilepsy (ILEA) classification, and Seizure Frequency Reduction
        - All-cause mortality, including Sudden Unexpected Death in Epilepsy (SUDEP)
        - Serious Adverse Events (bleeding/intracranial haemorrhage, infection, unexpected permanent functional deficits, functional outcomes, or complications that are potentially ECoG related, neurological or visual field deficits)
        - Quality of life (QoL) *(by any measure reported)*
        - Intraoperative seizures
        - Patient satisfaction (*reported by any tool or measure*)
        - Medical or medication-related adverse events
        - Post-operative depression or anxiety

2. **PICO 2: Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?**

- Population(s): All patients undergoing resective brain surgery with intraoperative ECoG
- Intervention(s): Complete resection of the area with intraoperative ECoG pathological findings
- Comparator(s): Incomplete resection or no resection of the area with pathological findings, as identified by intraoperative ECoG
- Outcome(s): *[In order of Work Group priority/importance rating]*
    - Post-operative seizure outcomes - as reported by any Engel or International League Against Epilepsy (ILEA) classification, and Seizure Frequency Reduction
    - All-cause mortality, including Sudden Unexpected Death in Epilepsy (SUDEP)
    - Serious Adverse Events (bleeding/intracranial haemorrhage, infection, unexpected permanent functional deficits, functional outcomes, or complications that are potentially ECoG related, neurological or visual field deficits)
    - Quality of life (QoL) *(by any measure reported)*
    - Intraoperative seizures
    - Patient satisfaction (*reported by any tool or measure*)
    - Medical or medication-related adverse events
    - Post-operative depression or anxiety

PICO 3: Do psychological and psychiatric outcomes differ among patients undergoing awake vs. asleep intraoperative ECoG recording?

- Population(s): All patients undergoing resective brain surgery with intraoperative ECoG
- Intervention(s): Awake resection with intraoperative ECoG
- Comparator(s): Asleep resection with intraoperative ECoG
- Outcome(s):
    - Post-operative seizure outcomes - as reported by any Engel or International League Against Epilepsy (ILEA) classification, and Seizure Frequency Reduction
    - Quality of life (QoL) *(by any measure reported)*
    - Intraoperative seizures
    - Pre-operative hesitation to undergo surgery with awake intraoperative ECoG
    - Intraoperative patient discomfort
    - Post-operative patient satisfaction
    - Post-operative psychosis
    - Medical or medication-related adverse events
    - Post-operative pain
    - Post-operative depression or anxiety

Study designs

For all the PICO questions we included comparative study designs such as randomized controlled trials (RCTs) and non-randomized studies (NRS) of interventions, which included prospective and retrospective cohort studies, crossover studies, and case-control studies.

Population Subgroups

We undertook a meta-analysis of subgroups identified in the protocol for which data was reported separately in a minimum of nine papers. Classification of the population subgroups as lesional, non-lesional, or genetic was undertaken by two experts from the guideline panel: Dr. Olga Selioutski (all clinical classifications) and Marissa Kellogg (non-genetic classification).

PICO considerations changed from the protocol

Based on clinical use of the different classification systems in the literature, the panel agreed to combine the values for Engel I vs II-IV, Engel IA vs all, ILAE 1-2 vs 3-6 and dichotomous "seizure free" at four different time points post-operation (≤ 2 weeks, >2 weeks to ≤ 6 months, >6 months to ≤1 year, and >1 year) rather than separately as outlined in the protocol. This analysis was the basis for the Evidence to Decision (EtD) discussion. A secondary, more inclusive classification of Engel I-II vs III-IV, ILAE 1-3 vs 4-6 and dichotomous "seizure free" was also analyzed and reported in Appendix 5. The panel also agreed on a 5% clinically important difference (i.e. the threshold for meaningful patient benefit) for the outcome of post-operative seizures.

Search strategies

The search strategy was developed and run by Becky Skidmore, MLS on behalf of AES (see Appendix 1).

The following databases were searched for primary studies: Cochrane Central Register of Controlled Trials (CENTRAL) via EBM Reviews (Ovid) and MEDLINE (Ovid) from the earliest possible date to 4 April 2024; Embase (OVID) was searched from 1 Jan 1992 to 8 May 2024.

In addition, an overarching search for secondary evidence including systematic reviews and clinical practice guidelines was also conducted in the MEDLINE and EMBASE databases on 4 April and 8 May 2024 respectively (see Appendix 1). The reference list of relevant reviews was screened for potentially eligible studies.

Selection of studies

Two AES members independently screened all citations and abstracts identified in the search at the abstract level using COVIDENCE (Veritas Health Innovation Ltd). Potentially eligible studies were then independently screened by two review Cochrane Response authors using DistillerSR (DistillerSR Inc.). Disagreements were resolved by consensus, by involving a third reviewer, or in consultation with a content expert.

To avoid including separate papers reporting on the data, we screened for multiple publications of the same study to identify companion papers and ensure each study was included only once.

Data extraction and management

One experienced reviewer extracted data using pre-tested data extraction forms in Distiller SR. A second reviewer validated the extracted data and any disagreements about data extraction were resolved by discussion.

Assessment of risk of bias

One experienced reviewer assessed the risk of bias of each included study using the Cochrane Risk of Bias Tool (RoB 2) or ROBINS-I in DistillerSR. A second reviewer verified the assessments with any disagreements resolved through discussion.

Data analysis

Singular and pooled data were analyzed in RevMan Web. For the dichotomous outcomes, we calculated odds ratios (OR) with their respective 95% confidence intervals (CIs). When a study reported only OR and not individual group data, we used the generic inverse variance (GIV) method. All meta-analyses used the random effects model.

Summarising and interpreting results

Benefits and harms

We used the GRADE approach to interpret findings and created an evidence profile for each PICO question following the GRADE handbook[2]. The tables provide the effect estimate and the associated certainty of evidence for each outcome of interest. It also allows us to judge the overall certainty of evidence for the PICO question.

Certainty of evidence started at high certainty, and was downgraded to moderate, low or very low for the following reasons: limitations in study design or execution (risk of bias), inconsistency of results, indirectness of evidence, imprecision, or publication bias.

Contextual factors

This systematic review focuses on benefits and harms of ECoG in patients undergoing resective brain surgery. The results are summarised as desirable and undesirable effects in the EtD, along with the overall certainty of evidence, to facilitate the guideline decision-making process. In addition, we collected contextual factors for the EtD framework of each PICO question from relevant records identified in the systematic review searches and from the discussion with the guideline development group.

Contextual factors include:

- Values: This describes the relative importance assigned to health outcomes by those affected by them; how such importance varies within and across populations; and whether this importance or variability is surrounded by uncertainty. The less uncertainty or variability there is about the values and preferences of people experiencing the critical or important outcomes, the greater the likelihood of a strong recommendation.
- Resources required / cost effectiveness: This pertains to how resource-intense an intervention is, whether it is cost–effective and whether it offers any incremental benefit. The more advantageous or clearly disadvantageous the resource implications are, the greater the likelihood of a strong recommendation either for or against the intervention.
- Equity: The greater the likelihood that the intervention will reduce inequities, improve equity or contribute to the realization of one or several human rights as defined under the international legal framework, the greater the likelihood of a strong recommendation.
- Acceptability: The greater the acceptability of an option to all or most stakeholders, the greater the likelihood of a strong recommendation.

- Feasibility: The greater the feasibility of an option from the standpoint of all or most stakeholders.

Results

Results of the search and screening

The PRISMA flow chart in Figure 1 illustrates the screening process for this systematic review. From the initial 12,355 records screened by AES, we assessed 887 full text records for eligibility and excluded 821 full texts. See Figure 1 for reasons for exclusion. Fifty-nine studies (reported in 66 records) were included in the systematic review.

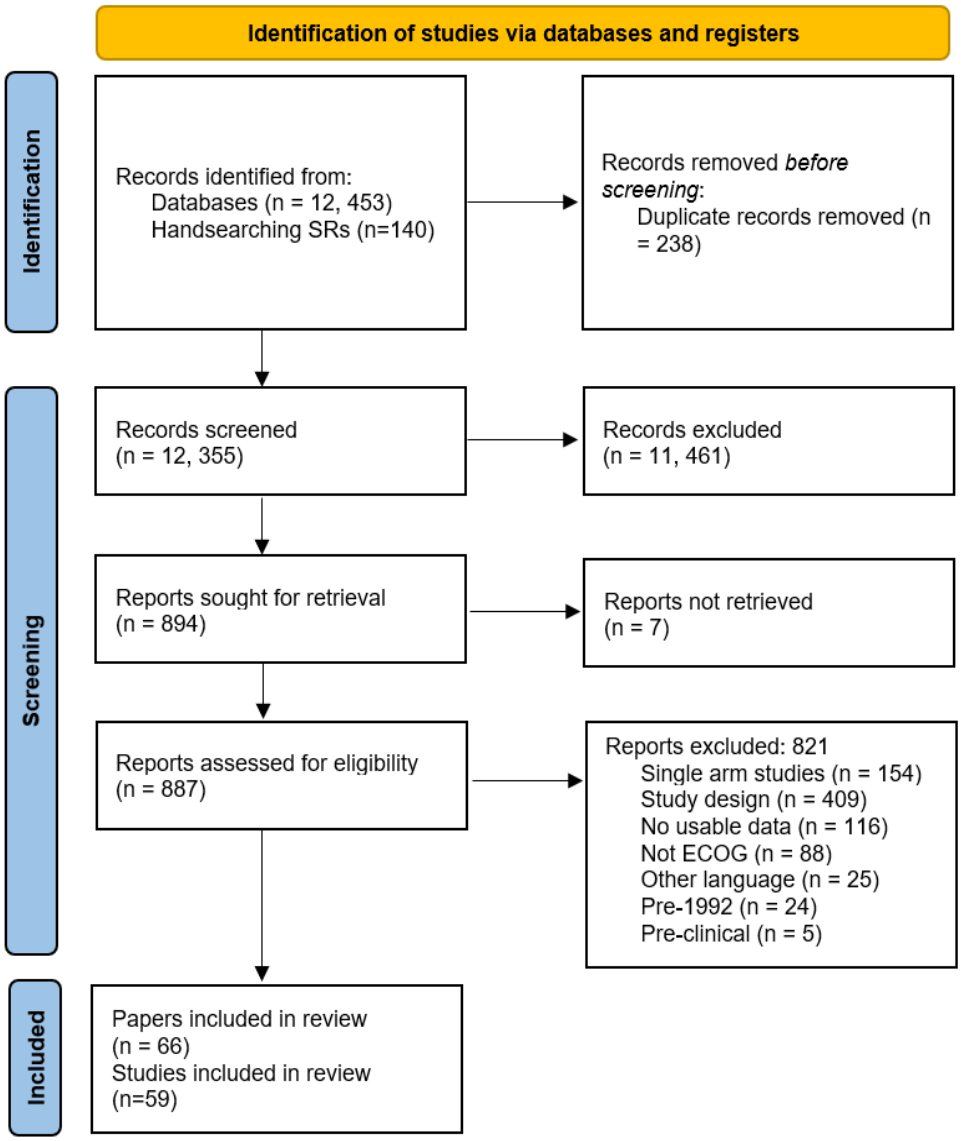


Figure 1. PRISMA flow chart illustrating screening and study selection

Included studies

For PICO 1 we identified 38 relevant studies, 21 for PICO 2 and three studies were identified for PICO 3. Three studies were included in both PICO 1 and 2.[3-5] The descriptive demographics of the included studies for each PICO are illustrated in Table 1. Detailed individual study characteristics can be found in Appendix 1. One study[6] included for PICO 1 only provided data in categories that could not be used for the primary data analysis, but did contribute to the secondary analysis (see Appendix 6).

Table 1. Descriptive demographics of included studies

PICO	Number of studies	Number of participants	Age groups	Countries	Years published	Outcomes reported
1	38* (1 RCT, 37 NRS)	38 (RCT), 3079 (NRS)	Children & adults: 45% (n=17) Children only: 34% (n=13) Adults only: 21% (n=8)	13: China (9), USA (9), Germany (4), Brazil (2), Canada (2) Israel (2), Russia (2), South Korea (2), Iran (1), Italy (1), Japan (1), Mexico (1)	2020-2024: 26% (n=10) 2010-2019: 61% (n=23) 2000-2009: 13% (n=5)	Post-operative seizure (n=38) Mortality (n=9) SAE (n=7) Intra-operative seizures (n=1)
2	21 (21 NRS)	574	Children & adults: 81% (n=17) Adults only: 4.8% (n=1) Children only: 4.8% (n=1) Unclear: 9.5% (n=2)	8: USA (14), Russia (2), Taiwan (2), Belgium (1), China (1), Denmark (1), Spain (1), UK (1)	2020-2024: (n=2) 2010-2019: (n=9) 2000-2009: (n=4) 1993-1999: (n=6)	Post-operative seizure (n=21) Mortality (n=3) SAE (n=1)
3	3 (3 NRS)	256	Adults only: 100% (n=3)	2: Italy (2), Egypt (1)	2020-2024: (n=2) 2000-2009: (n=1)	Intra-operative seizure (n=3) Post-operative seizure (n=1) SAE (n=1)

*One of the NRS studies[6] was only included in the secondary data analysis (see methods section)

Outcome results

For all the outcome results, see Appendix 2 for forest plots with meta-analyses and Appendix 3 for GRADE evidence profiles.

PICO 1.

Post-operative seizure

Thirty-seven studies (one RCT, 36 NRS)[3-39] reported post-operative seizure outcomes in patients receiving either ECoG or no ECoG. The outcomes were measured using Engel Classification (one RCT, 28 NRS), International League Against Epilepsy (ILAE) Classification (four NRS) or no formal classification method (three NRS).

For post-operative seizures occurring ≤2 weeks, evidence from one NRS (n=119)[11] suggests that there may be a higher risk of seizures in the ECoG group compared to no ECoG (53.1% vs 68.6% seizure free, OR 0.52, 95% CI 0.24 to 1.10) with a very low certainty of evidence.

For post-operative seizures occurring >2 weeks to ≤6 months, two NRS (n=151)[28,34] suggest there may be little to no difference in the risk of seizures with ECoG compared to no ECoG (92.8% vs 92.3%, OR 1.07, 95% CI 0.38 to 3.04); however, the certainty of the evidence is very low.

For post-operative seizures occurring >2 weeks to ≤6 months, two NRS (n=151)[28,34] suggest there may be little to no difference in the risk of seizures with ECoG compared to no ECoG (92.8% vs 92.3%, OR 1.07, 95% CI 0.38 to 3.04); however, the certainty of the evidence is very low.

For post-operative seizures occurring >6 months to ≤1 year, six NRS (n=487)[3,4,13,28,34,37] suggest that use of ECoG compared to no ECoG may result in more people being seizure free (74.4% vs 68.8%, OR 1.34, 95% CI 0.59 to 3.06) with a very low certainty of evidence.

Evidence from one RCT (n=42)[24] suggests that use of ECoG compared to no ECoG may result in little to no difference in the risk of post-operative seizures at >1 year follow-up (98.8% vs 94.7%, OR 3.81, 95% CI 0.15 to 99.08), with a very low certainty of the evidence.

For post-operative seizures occurring >1 year, 30 NRS (n=1479)[4,7-10,12,13,15-23,25-36,38,39] with a very low certainty of evidence reported there may be a potential reduction in risk of seizures. The overall effect was statistically, but not clinically significant with unadjusted OR 1.43 (95% CI 1.03 to 1.99).

Mortality

Nine NRS (n= 529)[7,14,15,22,23,33-35,39] with very low certainty of evidence reported on mortality as an outcome in patients receiving ECoG or no ECoG. Only one study reported any deaths, with one death in each arm, both from brain edema.[35] Both patients died in the first week post-surgery. No other deaths were reported in any time frame.

Serious Adverse Events

Seven studies (one RCT (n=42, low certainty evidence)[24]; six NRS (n=289, very low certainty of evidence)[5,22,30,32,33,39]) reported on serious adverse events (SAE) as an outcome in patients receiving ECoG or no ECoG. There was no clinically important difference between the two groups (0 fewer SAE per 100, ranging from 4 fewer to 15 more for the six NRS). All the SAE were reported 16 months or more post-operative. A total of 15 SAE were reported: stroke (1), hemorrhage (2), cerebral edema (2), extradural hematoma (1), transient hemiparesis (2), and permanent complications of mild aphasia (2), diplopia (1), nystagmus (1), superior quadrantanopsia (1), mild hemiparesis (1), and mild memory impairment (1).

Intra-operative seizure

One NRS of 477 patients[40] (very low certainty of evidence) reported on intra-operative seizures as an outcome. The unadjusted comparison reported intra-operative seizures were more frequent in patients receiving ECoG compared to those who did not (unadjusted OR 2.11 (95% CI 1.19 to 3.73;

p=0.01)). The wide confidence interval indicates there can be a substantial increase to no clinically relevant difference in the proportion of people who experience intra-operative seizures (8 more per 100 ranging from 1.5% more to 17.3% more).

Subgroup analysis

Evidence in the lesion subgroup, 28 non-randomized studies (166 patients, very low certainty of evidence) suggest there may be a lower risk of postoperative seizures with ECoG compared to no ECoG at >1 year follow up (OR 1.45, 95% CI 1.03, 2.04, p=0.03).

For the outcome of postoperative seizure in the temporal location subgroup, nine NRS (272 patients, very low certainty of evidence) reported no clinical or statistical difference between use of ECoG compared to no ECoG (OR 1.77, 95% CI 0.59, 5.27, p=0.31).

In the low-grade tumor subgroup, ten NRS (495 patients, very low certainty of evidence) reported little to no difference in the risk of postoperative seizures with ECoG compared to no ECoG at >1 year follow up (OR 1.17, 95% CI 0.72 , 1.89, p=0.54).

The non-genetic subgroup excluded patients with cavernomas, focal cortical dysplasia (FCD) and mixed population studies. For the outcome of postoperative seizure >1 year follow up, 24 non-randomized studies (959 patients, very low certainty of evidence) reported no clinical or statistically significant difference between use of ECoG compared to no ECoG (OR 1.40, 95% CI 0.85, 2.30, p=0.18).

PICO 2.

Post-operative seizure

Twenty-one NRS[3-5,41-58] reported post-operative seizure outcomes in patients receiving either complete or incomplete resection, as defined by abnormal ECOG findings. The outcomes were measured using Engel Classification (nine NRS), ILAE Classification (four NRS) or no formal classification method (seven NRS).

For post-operative seizures occurring >6 months to ≤1 year, three NRS (n=205)[3,4,46] with very low certainty of evidence suggest that complete resection may result in more people being “seizure free” (81.0% vs 56.2%, OR 1.23, 95% CI 0.04 to 42.12).

For post-operative seizures occurring >1 year, 19 NRS (n=1295)[4,5,41-45,47-58] with a very low certainty of evidence, reported a clinically important difference in the number of seizure free patients, with 23 more patients out of 100 being seizure free (ranging from 7.6% more to 34.5% more) in the complete resection group. The overall effect was statistically significant with unadjusted OR 2.82 (95% CI 1.36 to 5.84).

Mortality

One NRS[45] (n=46, very low certainty of evidence) reported no deaths in either arm for surgical mortality. Two NRS[53,55] (n=50, very low certainty of evidence) reported no deaths in either arm for postoperative mortality.

Serious Adverse Events

One NRS[55] (n=24, very low certainty of evidence) reported no neurological complications at median 30 months post-operation in either arm.

Subgroup analysis

For the outcome of postoperative seizure in the temporal location subgroup, nine NRS (676 patients, very low certainty of evidence) reported no clinical or statistical difference between use of ECoG compared to no ECoG (OR 1.94, 95% CI 1.33, 2.84, p=0.34).

PICO 3.

The data from the three included studies[59-61] could not be pooled for meta-analysis, with each outcome of interest having only one small (n<155) study. The panel discussion regarding the small amount of evidence reported for PICO 3 resulted in three key points:

1. The panel agreed that it does not have the evidence needed for a recommendation for PICO #3.
2. A good practice statement (GPS) is a good solution to addressing the concepts in PICO #3.
3. The panel does agree that this question is important to address, even though they cannot make a recommendation.

As a result of the discussion, the panel followed the GRADE GPS statement development process to develop a GPS.

> Good Practice Statement: For patients undergoing intra operative ECOG recording, instituting pre- and post-surgical psychological and psychiatric assessments should be considered.

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Conflicts of interest

All authors declare no financial or non-financial conflicts of interest.

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Appendix 1: Search Strategies

Intraoperative ECoG - **Final Strategies**
NOTE – The following includes:
- Ovid MEDLINE and Cochrane Library Search Strategies, results added 2024 Apr 4.
- Embase Search Strategies, results added 2024 May 8

MEDLINE
Results downloaded and grouped by study design (Primary, Secondary)
Database: Ovid MEDLINE(R) ALL <1946 to April 04, 2024>
---
1 Electrocorticography/ (1773)
2 (electrocorticogra* or electro-corticogra*).tw,kw,kf. (4546)
3 (microelectrocorticogra* or micro-electrocorticogra* or microelectro-corticogra* or micro-electro-corticogra*).tw,kw,kf. (86)
4 ((electr* or cortic* or high-density or intraop* or intra-op* or EEG or epilep*) adj5 (ECoG or HDECoG or HD-ECoG or iopECoG or microECoG or micro-ECoG or muECoG)).tw,kw,kf. (2638)
5 ((intraop* or intra-op* or IO) adj3 (electroencephalogra* or electro-encephalogra*)).tw,kw,kf. (207)
6 ((intraop* or intra-op* or IO) adj3 corticogra*).tw,kw,kf. (26)
7 (cortic* adj3 (electroencephalogra* or electro-encephalogra*)).tw,kw,kf. (916)
8 (cortic* adj3 (eeg? or seeg? or s-eeg? or sdeeg? or sd-eeg? or veeg? or v-eeg?)).tw,kw,kf. (1990)
9 ((intracranial or intra-cranial) adj3 (electroencephalogra* or electro-encephalogra*)).tw,kw,kf. (1149)
10 ((intracranial or intra-cranial) adj3 (eeg? or seeg? or s-eeg? or sdeeg? or sd-eeg? or veeg? or v-eeg?)).tw,kw,kf. (2158)
11 (invasive adj3 (electroencephalogra* or electro-encephalogra*)).tw,kw,kf. (338)
12 (invasive adj3 (eeg? or seeg? or s-eeg? or sdeeg? or sd-eeg? or veeg? or v-eeg?)).tw,kw,kf. (824)
13 electr* corticogra*.tw,kw,kf. (38)
14 ((intraop* or intra-op* or IO) adj3 (eeg? or seeg? or s-eeg? or sdeeg? or sd-eeg? or veeg? or v-eeg?)).tw,kw,kf. (278)
15 or/1-14 (11773)
Annotation: [ELECTROCORTICOGRAPHY]
16 exp Craniotomy/ (18133)
17 (craniotom* or cranio-tom*).tw,kw,kf. (18411)
18 exp Epilepsy/su [surgery] (11888)
19 exp Brain/su [surgery] (32607)
20 exp Neurosurgical Procedures/ (217373)
21 ((epilep* or brain) adj3 (neurosurg* or neuro-surg* or resect* or re-sect* or surger* or operat* or procedur*)).tw,kf. (22133)
22 Anterior Temporal Lobectomy/ (918)
23 ((anteromedial* or antero-medial* or anteromesial* or antero-mesial* or extratempor* or extra-tempor* or tempor* or subtempor* or sub-tempor*) adj2 (ablat* or lobectom* or remov* or resect* or re-sect* or surg*)).tw,kw,kf. (7158)
24 ATLR.tw,kw,kf. (36)
25 Amygdala/su [surgery] (727)
26 (amygdalohippocampectom* or amygdalo-hippocampectom* or AHE or selAH).tw,kw,kf. (1351)
27 Hippocampus/su [surgery] (1337)

28 hippocampectom*.tw,kw,kf. (407)
29 hemispherotom*.tw,kw,kf. (367)
30 (hemispher* adj3 (remov* or disconnect* or disabl*)).tw,kw,kf. (405)
31 (transgyral* or transsulcal* or transsylvian* or trans-gyral* or trans-sulcal or trans-sylvian).tw,kw,kf. (563)
32 Surgical Procedures, Operative/ (56917)
33 ((surg* or operative* or operation*) adj5 (epilep* or seizur* or sclero* or convuls*)).tw,kw,kf. (16273)
34 corticectom*.tw,kw,kf. (146)
35 ((remov* or excis*) adj3 (cerebral cortex or cerebral cortice? or cerebral mantle?)).tw,kw,kf. (117)
36 ((remov* or excis*) adj3 (allocortex or allo-cortex or allocortice? or allo-cortice? or archipall* or cortex cerebri or insular cortex or insular cortice? or paleocortex or paleo-cortex or paleocortice? or paleo-cortice? or periallocortex or periallo-cortex or periallocortice? or periallo-cortice?)).tw,kf. (5)
37 or/16-36 (326529)
Annotation: [CRANIOTOMY, BRAIN/EPILEPTIC SURGERY]
38 exp Electroencephalography/ (173638)
39 (electroencephalogr* or electro-encephalogr* or eeg? or seeg? or s-eeg? or s-eeg? or sdeeg? or sd-eeg? or veeg? or v-eeg?).tw,kw,kf. (135443)
40 38 or 39 (213077)
Annotation: [EEG]
41 37 and 40 (11707)
Annotation: [CRANIOTOMY/BRAIN SURGERY + EEG]
42 15 or 41 (20823)
Annotation: [EXPANDED ELECTROCORTIGRAPHY]
43 exp Epilepsy/ (128689)
44 (epileps* or epilept*).tw,kw,kf. (170922)
45 exp Seizures/ (75877)
46 seizure*.tw,kw,kf. (149022)
47 convulsi*.tw,kw,kf. (29531)
48 Landau-Kleffner Syndrome*.tw,kw,kf. (456)
49 Lennox Gastaut Syndrome*.tw,kw,kf. (1670)
50 West syndrome*.tw,kw,kf. (1435)
51 Sturge-Weber Syndrome/ (1410)
52 ((sturge* or weber) adj (disease* or syndrome*)).tw,kw,kf. (2809)
53 ((infantile or nodding) adj2 spasm?).tw,kw,kf. (2950)
54 ((flexor or "in flexion") adj2 spasm?).tw,kw,kf. (132)
55 ((lightning or salaam) adj2 attack?).tw,kw,kf. (2)
56 hypsarrhythmi*.tw,kw,kf. (972)
57 or/43-56 (286037)
Annotation: [EPILEPSY]
58 42 and 57 (12728)
Annotation: [EXPANDED ELECTROCORTIGRAPHY - EPILEPSY]
59 exp Brain Neoplasms/ (174710)
60 ((brain or intracranial or intra-cranial) adj3 (adenocarcinoma* or adeno-carcinoma* or cancer* or carcinoma* or oncolog* or metasta* or neoplasm* or tumour* or tumor*)).tw,kw,kf. (98921)
61 (glioblastoma* or glio-blastoma* or glioma* or meningioma* or menin-gioma* or ependymoma* or ependy-moma* or oligodendroglioma* or oligodendro-glioma* or oligo-dendro-glioma* or oligo-dendroglioma*).tw,kw,kf. (135651)

62 or/59-61 (277054)
Annotation: [BRAIN CANCER]
63 42 and 62 (1141)
Annotation: [EXPANDED ELECTROCORTIGRAPHY - BRAIN CANCER]
64 58 or 63 (13052)
Annotation: [EXPANDED ELECTROCORTIGRAPHY - EPILEPSY, BRAIN CANCER]
65 exp Animals/ not Humans/ (5208746)
66 64 not 65 (11918)
Annotation: [ANIMAL-ONLY REMOVED]
67 (address or autobiography or bibliography or biography or comment or dictionary or directory or editorial or festschrift or historical article or interactive tutorial or lecture or legal case or legislation or news or newspaper article or patient education handout or personal narrative or portrait or video-audio media or webcast or (letter not (letter and randomized controlled trial))).pt. (2897642)
68 66 not 67 (11663)
Annotation: [OPINION PIECES, IRRELEVANT PUBLICATION TYPES REMOVED]
69 Systematic Review.pt. (257014)
70 exp Systematic Reviews as Topic/ (12996)
71 Meta Analysis.pt. (198171)
72 exp Meta-Analysis as Topic/ (29431)
73 (meta-analy* or metanaly* or metaanaly* or met analy* or integrative research or integrative review* or integrative overview* or research integration or research overview* or collaborative review*).tw,kw,kf. (309335)
74 (systematic review* or systematic overview* or evidence-based review* or evidence-based overview* or (evidence adj3 (review* or overview*)) or evidence map* or meta-review* or meta-overview* or meta-synthes* or mapping review? or rapid review* or "review of reviews" or scoping review? or umbrella review? or technology assessment* or HTA or HTAs).tw,kw,kf. (414411)
75 exp Technology Assessment, Biomedical/ (12297)
76 (cochrane or health technology assessment or evidence report or systematic reviews).jw. (23266)
77 Network Meta-Analysis/ (5936)
78 (network adj (MA or MAs)).tw,kw,kf. (22)
79 (NMA or NMAs or MTC or MTCs or MAIC or MAICs).tw,kw,kf. (10188)
80 indirect* compar*.tw,kw,kf. (3015)
81 (indirect treatment* adj1 compar*).tw,kw,kf. (526)
82 (mixed treatment* adj1 compar*).tw,kw,kf. (531)
83 (multiple treatment* adj1 compar*).tw,kw,kf. (237)
84 (multi-treatment* adj1 compar*).tw,kw,kf. (4)
85 simultaneous* compar*.tw,kw,kf. (1355)
86 mixed comparison?.tw,kw,kf. (46)
87 or/69-86 (614485)
88 68 and 87 (198)
Annotation: [SRs/MAs]
89 (controlled clinical trial or randomized controlled trial or pragmatic clinical trial or equivalence trial).pt. (702724)
90 "Clinical Trials as Topic"/ (201986)
91 exp "Controlled Clinical Trials as Topic"/ (178136)
92 (randomi#ed or randomi#ation? or randomly or RCT or placebo*).tw,kw,kf. (1279201)
93 ((singl* or doubl* or trebl* or tripl*) adj (mask* or blind* or dumm*)).tw,kw,kf. (204490)
94 trial.ti. (306225)
95 or/89-94 (1741417)

96 68 and 95 (243)
Annotation: [RCTs/CCTs]
97 controlled clinical trial.pt. (95521)
98 Controlled Clinical Trial/ or Controlled Clinical Trials as Topic/ (101190)
99 (control* adj2 trial).tw,kw,kf. (225480)
100 Non-Randomized Controlled Trials as Topic/ (1082)
101 (nonrandom* or non-random* or quasi-random* or quasi-experiment*).tw,kw,kf. (78013)
102 (nRCT or non-RCT).tw,kw,kf. (574)
103 Controlled Before-After Studies/ (755)
104 (control* adj3 ("before and after" or "before after")).tw,kw,kf. (5515)
105 Interrupted Time Series Analysis/ (2016)
106 time series.tw,kw,kf. (49653)
107 (pre- adj5 post*).tw,kw,kf. (203924)
108 ((pretest adj5 posttest) or (pre-test adj5 post-test)).tw,kw,kf. (12578)
109 Historically Controlled Study/ (233)
110 (control* adj2 study).tw,kw,kf. (219939)
111 Control Groups/ (2118)
112 (control* adj2 group?).tw,kw,kf. (654070)
113 trial.ti. (306225)
114 or/97-113 (1511162)
115 68 and 114 (614)
Annotation: [nRCTs]
116 exp Cohort Studies/ (2589940)
117 cohort?.tw,kw,kf. (931195)
118 Retrospective Studies/ (1192007)
119 (longitudinal* or prospective* or retrospective*).tw,kw,kf. (2223075)
120 consecutive*.tw,kw,kf. (526307)
121 (followup or follow-up).tw,kw,kf. (1277765)
122 Observational study.pt. (153955)
123 (observation$2 adj (study or studies)).tw,kw,kf. (179638)
124 ((population or population-based) adj (study or studies or analys#s)).tw,kw,kf. (28639)
125 ((multidimensional or multi-dimensional) adj (study or studies)).tw,kw,kf. (159)
126 Comparative Study.pt. (1913823)
127 ((comparative or comparison) adj (study or studies)).tw,kw,kf. (139953)
128 exp Case-Control Studies/ (1494115)
129 ((case-control* or case-based or case-comparison or case-compeer or case-referrent or case-referent) adj3 (study or studies)).tw,kw,kf. (147940)
130 Cross-Sectional Studies/ (497573)
131 (crosssection* or cross-section*).tw,kw,kf. (604925)
132 Multicenter Study.pt. (344493)
133 ((multicenter or multi-center or multicentre or multi-centre) adj (study or studies)).tw,kw,kf. (58986)
134 or/116-133 (6828968)
135 68 and 134 (4716)
Annotation: [OBSERVATIONAL STUDIES]
136 Guidelines as Topic/ (42115)
137 Practice Guidelines as Topic/ (127851)
138 clinical decision rules/ (951)
139 exp Clinical Protocols/ (193093)
140 Critical Pathways/ (7977)
141 Health Planning Guidelines/ (4165)

142 Guideline.pt. (16381)
143 Practice Guideline.pt. (31229)
144 standards.fs. (767703)
145 consensus/ (22508)
146 exp consensus development conferences as topic/ (3004)
147 Consensus Development Conference.pt. (12376)
148 Consensus Development Conference, NIH.pt. (801)
149 (position statement* or policy statement* or practice parameter* or best practice*).tw,kw,kf. (49733)
150 (standards or guideline or guidelines).ti,kw,kf. (142036)
151 ((practice or treatment* or clinical) adj guideline*).ab. (56460)
152 (CPG or CPGs).ti. (6573)
153 consensus*.ti,kw,kf. (37286)
154 consensus*.ab. /freq=2 (36777)
155 ((critical or clinical or practice) adj2 (path or paths or pathway or pathways or protocol*)).tw,kw,kf. (28421)
156 recommendat*.ti,kw,kf. or guideline recommendation*.ab. (62011)
157 ((care or healthcare or health care or treatment?) adj2 (standard or standards or path or paths or pathway or pathways or map or maps or plan or plans)).tw,kw,kf. (187415)
158 (algorithm* adj2 (screening or examination or test or tested or testing or assessment* or diagnosis or diagnoses or diagnosed or diagnosing)).tw,kw,kf. (11015)
159 (algorithm* adj2 (pharmacotherap* or chemotherap* or chemotreatment* or therap* or treatment* or intervention*)).tw,kw,kf. (13700)
160 (guideline* or standards or consensus* or recommendat*).au. (9)
161 or/136-160 (1506575)
162 68 and 161 (392)
Annotation: [CPGs]
163 88 or 96 or 115 or 135 or 162 (5367)
Annotation: [ALL STUDY DESIGNS]
164 Single-Case Studies as Topic/ (100)
165 163 not 164 (5366)
166 (review not (review and (Systematic Review or Meta Analysis or Controlled Clinical Trial or Randomized Controlled Trial or Pragmatic Clinical Trial or Equivalence Trial or Observational Study or Comparative Study or Multicenter Study))).pt. (3079367)
167 165 not 166 (5079)
168 limit 167 to yr="1992-current" (4804)
169 limit 163 to yr="1992-current" (5085)
170 96 or 115 or 135 (5079)
Annotation: [ALL PRIMARY STUDY DESIGNS]
171 88 or 162 (566)
Annotation: [ALL SR-MA-CPGs]
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Cochrane Library
April 04, 2024
#1 [mh Electrocorticography] 17
#2 (electrocorticogra* or (electro NEXT corticogra*)):ti,ab,kw 1155
#3 (microelectrocorticogra* or micro-electrocorticogra* or microelectro-corticogra* or(micro-electro-corticogra*)):ti,ab,kw 0
#4 ((electr* or cortic* or "high-density" or intraop* or intra-op* or EEG or epilep*) NEAR/5 (ECoG or HDECoG or "HD-ECoG " or iopECoG or microECoG or "micro-ECoG" or muECoG)):ti,ab,kw 100

#5 ((intraop* or intra-op* or "IO") NEAR/3 (electroencephalogra* or electro-encephalogra*)):ti,ab,kw 24
#6 ((intraop* or intra-op* or "IO") NEAR/3 corticogra*):ti,ab,kw 0
#7 (cortic* NEAR/3 (electroencephalogra* or electro-encephalogra*)):ti,ab,kw 67
#8 (cortic* NEAR/3 (eeg or eegs or seeg or seegs or "s-eeg" or "s-eegs" or sdeeg or sdeegs or "sd-eeg" or "sd-eegs" or veeg or veegs or "v-eeg" or "v-eegs")):ti,ab,kw 108
#9 ((intracranial or intra-cranial) NEAR/3 (electroencephalogra* or electro-encephalogra*)):ti,ab,kw 5
#10 ((intracranial or intra-cranial) NEAR/3 (eeg or eegs or seeg or seegs or "s-eeg" or "s-eegs" or sdeeg or sdeegs or "sd-eeg" or "sd-eegs" or veeg or veegs or "v-eeg" or "v-eegs")):ti,ab,kw 31
#11 (invasive NEAR/3 (electroencephalogra* or electro-encephalogra*)):ti,ab,kw 19
#12 (invasive NEAR/3 (eeg or eegs or seeg or seegs or "s-eeg" or "s-eegs" or sdeeg or sdeegs or "sd-eeg" or "sd-eegs" or veeg or veegs or "v-eeg" or "v-eegs")):ti,ab,kw 30
#13 (electr* NEXT corticogra*):ti,ab,kw 0
#14 ((intraop* or intra-op* or "IO") NEAR/3 (eeg or eegs or seeg or seegs or "s-eeg" or "s-eegs" or sdeeg or sdeegs or "sd-eeg" or "sd-eegs" or veeg or veegs or "v-eeg" or "v-eegs")):ti,ab,kw 49
#15 41-#14 1499
#16 [mh Craniotomy] 665
#17 (craniotom* or cranio-tom*):ti,ab,kw 1799
#18 [mh Epilepsy/SU] 175
#19 [mh Brain/SU] 486
#20 [mh "Neurosurgical Procedures"] 9177
#21 ((epilep* or brain) NEAR/3 (neurosurg* or neuro-surg* or resect* or re-sect* or surger* or operat* or procedur*)):ti,ab,kw 2937
#22 [mh "Anterior Temporal Lobectomy"] 34
#23 ((anteromedial* or antero-medial* or anteromesial* or antero-mesial* or extratempor* or extra-tempor* or tempor* or subtempor* or sub-tempor*) NEAR/2 (ablat* or lobectom* or remov* or resect* or re-sect* or surg*)):ti,ab,kw488
#24 ATLR:ti,ab,kw 3
#25 [mh Amygdala/SU] 19
#26 (amygdalohippocampectom* or amygdalo-hippocampectom* or AHE or selAH):ti,ab,kw 45
#27 [mh Hippocampus/SU] 30
#28 hippocampectom*:ti,ab,kw 10
#29 hemispherotom*:ti,ab,kw 5
#30 (hemispher* NEAR/3 (remov* or disconnect* or disabl*)):ti,ab,kw 3
#31 (transgyral* or transsulcal* or transsylvian* or trans-gyral* or trans-sulcal or trans-sylvian):ti,ab,kw 15
#32 [mh ^"Surgical Procedures, Operative"] 1404
#33 ((surg* or operative* or operation*) NEAR/5 (epilep* or seizur* or sclero* or convuls*)):ti,ab,kw 1066
#34 corticectom*:ti,ab,kw 2
#35 ((remov* or excis*) NEAR/3 ("cerebral cortex" or "cerebral cortice" or "cerebral cortices" or "cerebral mantle" or "cerebral mantles")):ti,ab,kw 1
#36 ((remov* or excis*) NEAR/3 (allocortex or "allo-cortex" or allocortice* or "allo-cortice" or "allo-cortices" or archipall* or "cortex cerebri" or "insular cortex" or "insular cortice" or "insular cortices" or paleocortex or "paleo-cortex" or paleocortice* or "paleo-cortice" or "paleo-cortices" or periallocortex or "periallo-cortex" or periallocortice* or "periallo-cortice" or "periallo-cortices")):ti,ab,kw 0
#37 {or #16-#36o 15084
#38 [mh Electroencephalography] 6643

#39 (electroencephalogr* or electro-encephalogr* or eeg or eegs or seeg or seegs or "s-eeg" or "s-eegs" or sdeeg or sdeegs or "sd-eeg" or "sd-eegs" or veeg or veegs or "v-eeg" or "v-eegs"):ti,ab,kw 15512
#40 #38 or #39 15749
#41 #37 and #40 319
#42 #15 or #41 1779
#43 [mh Epilepsy] 3481
#44 (epileps* or epilept*):ti,ab,kw 9881
#45 [mh Seizures] 1761
#46 seizure*:ti,ab,kw 10349
#47 convulsi*:ti,ab,kw 1881
#48 Landau-Kleffner Syndrome*:ti,ab,kw 13
#49 Lennox Gastaut Syndrome*:ti,ab,kw 334
#50 West syndrome*:ti,ab,kw 960
#51 [mh "Sturge-Weber Syndrome"] 11
#52 ((sturge* or weber) NEXT (disease* or syndrome*)):ti,ab,kw 67
#53 ((infantile or nodding) NEAR/2 spasm*):ti,ab,kw 322
#54 ((flexor or "in flexion") NEAR/2 spasm*):ti,ab,kw 24
#55 ((lightning or salaam) NEAR/2 (attack or attacks)):ti,ab,kw 1
#56 hypsarrhythmi*:ti,ab,kw 76
#57 {or #43-#56} 16998
#58 #42 and #57 280
#59 [mh "Brain Neoplasms"] 3189
#60 ((brain or intracranial or intra-cranial) NEAR/3 (adenocarcinoma* or adeno-carcinoma* or cancer* or carcinoma* or oncolog* or metasta* or neoplasm* or tumour* or tumor*)):ti,ab,kw 7313
#61 (glioblastoma* or glio-blastoma* or glioma* or meningioma* or menin-gioma* or ependymoma* or ependy-moma* or oligodendroglioma* or oligodendro-glioma* or oligo-dendro-glioma* or oligo-dendroglioma*):ti,ab,kw 4474
#62 {or #59-#61} 10194
#63 #42 and #62 86
#64 #58 or #63 353
#65 #64 in Cochrane Reviews, Cochrane Protocols, Trials 353
#66 #64 in Cochrane Reviews 4
#67 #64 in Cochrane Protocols 0
#68 #64 in Trials 349
#69 #65 with Cochrane Library publication date Between Jan 1992 and Dec 2024 353
#70 #68 with Cochrane Library publication date Between Jan 1992 and Dec 2024 349
Reviews – 4
Trials - 349
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Embase

8 May 2024
Results downloaded and grouped by study design (Primary, Secondary)
#1 'electrocorticography'/de 20005
#2 electrocorticogra*:ab,ti OR 'electro corticogra*':ab,ti 5731
#3 microelectrocorticogra*:ab,ti OR 'micro electrocorticogra*':ab,ti OR 'microelectro corticogra*':ab,ti OR 'micro electro corticogra*':ab,ti 105
#4 ((electr* OR cortic* OR 'high density' OR intraop* OR 'intra op*' OR eeg OR epilep*) NEAR/5 (ecog OR hdecog OR 'hd ecog' OR iopecog OR microecog OR 'micro ecog' OR muecog)):ab,ti 3525

#5 ((intraop* OR 'intra op*' OR io) NEAR/3 (electroencephalogra* OR 'electro encephalogra*')):ab,ti 218
#6 ((intraop* OR 'intra op*' OR io) NEAR/3 corticogra*):ab,ti 41
#7 (cortic* NEAR/3 (electroencephalogra* OR 'electro encephalogra*')):ab,ti 844
#8 (cortic* NEAR/3 (eeg$ OR seeg$ OR s-eeg$ OR sdeeg$ OR sd-eeg$ OR veeg$ OR v-eeg$)):ab,ti 2686
#9 ((intracranial OR 'intra cranial') NEAR/3 (electroencephalogra* OR 'electro encephalogra*')):ab,ti 1320
#10 ((intracranial OR 'intra cranial') NEAR/3 (eeg$ OR seeg$ OR s-eeg$ OR sdeeg$ OR sd-eeg$ OR veeg$ OR v-eeg$)):ab,ti 3186
#11 (invasive NEAR/3 (electroencephalogra* OR 'electro encephalogra*')):ab,ti 399
#12 (invasive NEAR/3 (eeg$ OR seeg$ OR s-eeg$ OR sdeeg$ OR sd-eeg$ OR veeg$ OR v-eeg$)):ab,ti 1362
#13 (electr* NEXT/1 corticogra*):ab,ti 56
#14 ((intraop* OR 'intra op*' OR io) NEAR/3 (eeg$ OR seeg$ OR s-eeg$ OR sdeeg$ OR sd-eeg$ OR veeg$ OR v-eeg$)):ab,ti 409
#15 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 30222
#16 'craniotomy'/exp 42330
#17 craniotom*:ab,ti OR 'cranio tom*':ab,ti 24589
#18 'epilepsy'/exp/dm_su 14585
#19 'brain'/exp/dm_su 6354
#20 'neurosurgery'/exp 351362
#21 ((epilep* OR brain) NEAR/3 (neurosurg* OR 'neuro surg*' OR resect* OR 're sect*' OR surger* OR operat* OR procedur*)):ab,ti 31108
#22 'temporal lobectomy'/exp 5414
#23 ((anteromedial* OR 'antero medial*' OR anteromesial* OR 'antero mesial*' OR extratempor* OR 'extra tempor*' OR tempor* OR subtempor* OR 'sub tempor*') NEAR/2 (ablat* OR lobectom* OR remov* OR resect* OR 're sect*' OR surg*)):ab,ti 9193
#24 atlr:ab,ti 85
#25 'amygdala'/exp/dm_su 155
#26 amygdalohippocampectom*:ab,ti OR 'amygdalo hippocampectom*':ab,ti OR ahe:ab,ti OR selah:ab,ti1543
#27 'hippocampus'/exp/dm_su 157
#28 hippocampectom*:ab,ti 570
#29 hemispherotom*:ab,ti 650
#30 (hemispher* NEAR/3 (remov* OR disconnect* OR disabl*)):ab,ti551
#31 transgyral*:ab,ti OR transsulcal*:ab,ti OR transsylvian*:ab,ti OR 'trans gyral*':ab,ti OR 'trans sulcal':ab,ti OR 'trans sylvian':ab,ti 646
#32 'surgery'/de 843667
#33 ((surg* OR operative* OR operation*) NEAR/5 (epilep* OR seizur* OR sclero* OR convuls*)):ab,ti 23968
#34 corticectom*:ab,ti 223
#35 ((remov* OR excis*) NEAR/3 ('cerebral cortex' OR 'cerebral cortice' OR 'cerebral cortices' OR 'cerebral mantle' OR 'cerebral mantles')):ab,ti 120
#36 ((remov* OR excis*) NEAR/3 (allocortex OR 'allo-cortex' OR allocortice$ OR 'allo-cortice' OR 'allo-cortices' OR archipall* OR 'cortex cerebri' OR 'insular cortex' OR 'insular cortice' OR 'insular cortices' OR paleocortex OR 'paleo-cortex' OR paleocortice$ OR 'paleo-cortice' OR 'paleo-cortices' OR periallocortex OR 'periallo-cortex' OR periallocortice$ OR 'periallo-cortice' OR 'periallo-cortices')):ab,ti 6

#37 #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 1203515
#38 'electroencephalography'/exp 176780
#39 electroencephalogr*:ab,ti OR 'electro encephalogr*':ab,ti OR eeg$:ab,ti OR seeg$:ab,ti OR s-eeg$:ab,ti OR sdeeg$:ab,ti OR sd-eeg$:ab,ti OR veeg$:ab,ti OR v-eeg$:ab,ti 185731
#40 #38 OR #39 272957
#41 #37 AND #40 20810
#42 #15 OR #41 44348
#43 'epilepsy'/exp 305579
#44 epileps*:ab,ti OR epilept*:ab,ti 246158
#45 'seizure'/exp 238910
#46 seizure*:ab,ti 226886
#47 convulsi*:ab,ti 39520
#48 'landau-kleffner syndrome':ab,ti 677
#49 'lennox gastaut syndrome':ab,ti 2623
#50 'west syndrome':ab,ti 2043
#51 'sturge-weber syndrome'/exp 2666
#52 ((sturge* OR weber) NEAR/1 (disease* OR syndrome*)):ab,ti 3611
#53 ((infantile OR nodding) NEAR/2 spasm$):ab,ti 4273
#54 ((flexor OR 'in flexion') NEAR/2 spasm$):ab,ti 189
#55 ((lightning OR salaam) NEAR/2 attack$):ab,ti 2
#56 hypsarrhythmi*:ab,ti 1447
#57 #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56 496866
#58 #42 AND #57 20397
#59 'brain tumor'/exp 251336
#60 ((brain OR intracranial OR 'intra cranial') NEAR/3 (adenocarcinoma* OR 'adeno carcinoma*' OR cancer* OR carcinoma* OR oncolog* OR metasta* OR neoplasm* OR tumour* OR tumor*)):ab,ti 139962
#61 glioblastoma*:ab,ti OR 'glio blastoma*':ab,ti OR glioma*:ab,ti OR meningioma*:ab,ti OR 'menin gioma*':ab,ti OR ependymoma*:ab,ti OR 'ependy moma*':ab,ti OR oligodendroglioma*:ab,ti OR 'oligodendro glioma*':ab,ti OR 'oligo dendro glioma*':ab,ti OR 'oligo dendroglioma*':ab,ti 189916
#62 #59 OR #60 OR #61 419033
#63 #42 AND #62 2643
#64 #58 OR #63 21587
#65 ('animal'/exp OR 'animal model'/exp OR 'animal experiment'/exp OR 'nonhuman'/exp OR 'vertebrate'/exp) NOT ('human'/exp OR 'human experiment'/exp) 8015556
#66 #64 NOT #65 19774
#67 'systematic review'/de 464790
#68 'systematic review (topic)'/de 34617
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Appendix 2: Study characteristics and risk of bias assessments

PICO 1: Should intraoperative electrocorticography (ECoG), compared to no intraoperative ECoG, be used for patients undergoing resective brain surgery?

Randomized Controlled Trials

Study details	Country – setting/location	Population	Type of lesion/tumor	Inclusion/exclusion criteria	Outcomes	ROB score (ROB 2)
Rajeev 2024[24] RCT June 2020 to January 2022	India - Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala	Patients with long-term epilepsy associated tumors (LEATs) (in non-eloquent locations) and drug-resistant epilepsy who underwent primary surgical resections. N=42 Age (mean (SD), range): children 11.11 (4.72), 2-18 years; adult 29.56 (9.29) 19-59 years. No. males: 27, 64.3%	Long-term epilepsy associated tumors (LEATs)	Inclusion: pediatric patients (age < 18 years) and adults with LEATs (in non-eloquent locations) and drug-resistant epilepsy who underwent primary surgical resections. Exclusion: Re-operations for failed seizure control or tumor recurrence and eloquent cortex lesions.	Postoperative seizure (Engel) SAE	Some Concerns (unblinded outcome assessment, outcomes not reported in registry).

Non-Randomized Studies

Study details	Country – setting/location	Population	Type of lesion/tumor	Inclusion/exclusion criteria	Outcomes	ROB score (ROBINS I)
Benifla 2017[7]	Israel - Two neurosurgery departments	Children with normal hippocampus on MRI, who underwent surgery for medically refractory	Temporal	Inclusion: Children <18 years with temporal lesions involving the gyri adjacent to the hippocampus and with normal hippocampal appearance	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders;

NRS - Case series n>20 January 2008 to December 2015		intractable temporal lobe epilepsy. N=22 Age (mean): 11.3 years No. males: 11, 50%		on MRI. We also included patients with non-lesional epilepsy and normal MRI; availability of follow-up data for at least one year. Exclusion: children with cortical based lesions that were distant from the hippocampus by at least one gyrus gap and children with mesial temporal sclerosis and any hippocampal abnormality as per MRI.		unblinded outcome assessment)
Budnick 2022[8] NRS -Cohort study with control group January 2000 to December 2017	USA - Indiana University School of Medicine at Riley Hospital for Children in Indianapolis, IN	Patients <18 years old diagnosed with WHO Grade I and II gliomas N=42 Age (mean): 9.76 years No. males: 18, 42.9%	Low-grade gliomas	Inclusion: surgical resection or biopsy, age <18 years at diagnosis, follow-up for at least one year, and pathologic diagnosis of low-grade glioma (grade I or II) as determined by a board-certified pathologist. Exclusion: Posterior fossa and purely intraventricular lesions due to their typical non-epileptogenic nature. Patients who had lifelong or pre-existing epilepsy if it was clear that the epilepsy was present before the tumor.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Chang 2010[3] NRS -Case series n>20	USA - University of California, San Francisco	Patients who underwent resection of dysembryoplastic neuroepithelial tumors (DNETs) N=50	Dysembryoplastic neuroepithelial tumors (DNETs)	Inclusion: Patients who underwent resection of DNETs were included if they had not undergone any prior resection for their tumor, or if only biopsies were performed as part of a diagnostic workup. All included patients had histologically confirmed DNETs according to WHO criteria.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

January 1990 to April 2006		Age (median, range): 21, 4-46 years No. males: 33, 66%				
Englot 2014[9] NRS - Case NRS - series n>20 January 1997 to December 2011	USA - University of California, San Francisco (UCSF), and the Children's Hospital and Research Center Oakland (CHRCO)	Children and adolescents with focal epilepsy N=110 Age (mean, range): 12.3 years, 6 months – 19 years No. males: 66, 60%	Varied	Inclusion: Pediatric patients (ages 0–19 years). All patients suffered from drug-resistant epilepsy, defined as persistent seizures after at least 2 unsuccessful antiepileptic medication regimens. Surgical cases involving focal lesionectomy, lobar resection, or limited multilobar resection for drug-resistant epilepsy were included. A minimum of 1 year of postoperative follow-up was required. Exclusion: We excluded functional or anatomical hemispherectomy procedures, disconnection-only procedures (e.g., corpus callosotomy), and device implantations (e.g., vagus nerve stimulator).	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Englot 2015[10] NRS -Case series n>20 June 2004 to June 2013	USA - University of California, San Francisco (UCSF)	Patients with focal epilepsy. N=132 Age (mean, range): 27.3 years, 3-68 years No. males: 73, 55%	Varied	Inclusion: Patients with focal epilepsy who underwent magnetoencephalography (MEG) followed by resective epilepsy surgery at the study institution. Exclusion: Patients without at least one year of post-operative follow-up.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

Feyissa 2019[12] NRS -Case series n>20 October 2016 to August 2018	USA - Mayo Clinic, Florida	Adult patients with glioma. N=68 Age (mean): 51 years No. males: 45, 66.2%	Glioma	Exclusion: Patients with non-glial brain tumors including dysembryoplastic neuroepithelial tumors, gangliogliomas, papillary glioneuronal tumor, and hemangiopericytoma.	Postoperative seizure (no classification)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Feyissa 2023[11] NRS -Case series n>20 January 2018 to July 2022	USA - Mayo Clinic Florida	Patients with glioblastoma (GBM) who underwent resection surgery. N=119 Age (mean): 60.92 years No. males: 70, 59%	Glioblastoma	Inclusion: Patients with GBM who underwent resection surgery. Exclusion: Patients with indeterminate and mutated IDH1 status; Molecular GBMs, including IDH1 wild-type astrocytomas.	Postoperative seizure (no classification)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Gelinas 2011[13] NRS -Case series n>20 1984 to 2008	Canada - British Columbia Children's Hospital (BCCH), Vancouver	Pediatric patients who underwent surgery for lesional epilepsy. N=67 Age (mean-ECOG): 9.53 years, (No ECOG): 8.75 years No. males: 39, 58%	Varied lesion types	Inclusion: Pediatric patients were included if they had recurrent seizures attributable to a discrete lesion on neuroimaging (computed tomography (CT) or magnetic resonance imaging (MRI)), had tried at least one antiepileptic medication prior to surgery, and had surgical lesionectomy with or without ECoG-guided cortical resection. Patients who had elements of focal	Postoperative seizure (Engel)	Critical (statistical adjustment for confounders but no details; unblinded outcome assessment)

				cortical dysplasia on neuropathological examination in addition to a tumor were not excluded. Exclusion: Patients with a single seizure secondary to a lesion were not included. Patients were excluded if their epilepsy was caused by mesial temporal lobe sclerosis, diffuse hemispheric disorders, or malformations of cortical development.		
Hader 2004[6] NRS -Case series n>20 April 1989 to January 2001	Canada - The Hospital for Sick Children, University of Toronto, Ontario	Pediatric patients with pathologically proven focal cortical dysplasia (FCD) who underwent surgery for intractable epilepsy. N=39 Age (mean, range): 9.6, 2 months to 18.5 years. No. males: 16, 41%	Focal cortical dysplasia (FCD)	Inclusion: Pediatric patients who underwent surgery for intractable epilepsy and in whom there was evidence of FCD on pathological examination at the Hospital for Sick Children. Minimum follow up of 1.5 years. Exclusion: Patients with hemimegalencephaly, bilateral cortical dysplasia, schizencephaly, or dysembryoplastic neuroepithelial tumor.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
He 2022[14] NRS -Case series n>20 January 2005 to	China -Fudan/Shanghai	Patients with mesial temporal lobe cavernoma (MTC)-associated epilepsy. N=53 Age (mean, range): 32.0, 1-58 years	Mesial temporal lobe cavernoma	Inclusion: Patients diagnosed with temporal lobe epilepsy and where the presence of a mesial temporal lobe cavernoma was radiologically confirmed by magnetic resonance imaging (MRI). Exclusion: Patients with multiple	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

December 2013		No. males: 26, 49.1%		cavernomas or patients who refused to join the study.		
Hu 2012[15] NRS -Case series n>20 September 2003 to May 2010	China - Beijing Tiantan Hospital	Patients with epileptogenic gangliogliomas. N=55 Age (mean): 19.39 years No. males: 30, 54%	Ganglioglioma	Patients with ganglioglioma who had a history of epilepsy and underwent surgery at Beijing Tiantan Hospital.	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Huang 2013[16] NRS -Case series n>20 January 2009 to June 2011	China - West China Hospital of Sichuan University	Patients with cavernous malformations who underwent surgical treatment. N=52 Age (mean (SD)): 36.2 (13.4) years No. males: 33, 63.5%	Cavernous malformations	Inclusion: Patients with cavernous malformations confirmed by pathology after surgery. Exclusion: Patients who were clinically diagnosed with CMs on the evidence of neuroimaging but confirmed as other type of vascular malformations such as AVMs.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Im 2002[17] NRS -Case series n>20 1987 to 1999	South Korea - Seoul National University Hospital, Seoul National University Children's Hospital	Epileptic patients with gangliogliomas. N=29 Age (mean (SD), range): 16.5 (12.3), 14 months to 50 years N=19, 65.5%	Gangliogliomas	Inclusion: Patients with supratentorial gangliogliomas who presented with epilepsy and were treated at both Seoul National University Hospital and Seoul National University Children's Hospital between 1987 and 1999.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Kuang 2024[4]	Three epilepsy centers in Beijing	Patients with low-grade epilepsy-associated brain tumors (LEATs) who	Low-grade epilepsy-	Inclusion: Patients with lesion-associated epilepsy; postoperative pathology was diagnosed as LEAT and	Postoperative seizure (ILAE)	Critical (no statistical adjustment for

NRS -Case series n>20 October 2010 to April 2023		underwent resective surgery. N=111 Age (mean (SD), range): 16.85 (15.69), 0.3-48 years No. males: 69, 62.2%	associated brain tumors (LEATs)	tumor were classified as grade WHO I or grade WHO II; children or adults with at least 1-year follow-up. Exclusion: Subjects undergoing other neurosurgical operations for reasons other than epilepsy; patients without outcome of seizure control at 1-year follow-up; cases with incomplete clinical data.		confounders; unblinded outcome assessment)
Lee 2000[18] NRS -Case series n>20 January 1988 to December 1998	South Korea -Seoul National University Hospital	Patients with dysembryoplastic neuroepithelial tumor (DNT) N=20 Age (range): 4 -53 years No. males: 12, 60%	Dysembryoplastic neuroepithelial tumor (DNT)	Inclusion: patients diagnosed with DNT based on characteristic histological findings treated at the study institution.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Mehvari Habibabadi 2021[19] NRS -Case series n>20 June 2014 to June 2019	Iran - Kashani Comprehensive Epilepsy Center, Isfahan	Adult patients (16 years and older) with lesional and drug-resistant epilepsy. N=148 Age (mean): 30.45 years No. males: 88, 59.5%	Multiple - majority (60.1%) were mesial temporal sclerosis	Inclusion: All adult patients (16 years and older) with lesional and drug-resistant epilepsy (defined as treatment failure with 2 or more appropriately selected and used antiepileptic drugs (AEDs)), who had undergone epilepsy surgery Exclusion: Patients who underwent non-resectional epilepsy surgery or had incomplete medical documents	Postoperative seizure (Engel)	Critical (statistical adjustment for confounders but no details; unblinded outcome assessment)

Melikyan 2020[21] NRS -Case series n>20 2006 to 2018	Russia - Burdenko Neurosurgery Center, Moscow	Children with focal cortical dysplasia (FCD) N=169 Age (median): 6.4 years No. males: 94, 55.6%	Focal cortical dysplasia	Inclusion: age <18 years and morphologically verified cortical malformation. Exclusion: hemimegalencephaly and tuberous sclerosis.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment; missing data)
Melikyan 2020[20] NRS -Case series n>20 2006 to 2017	Russia - Burdenko Neurosurgical Center, Moscow	Children with gloneuronal brain tumors. N=152 Age (median): 8 years No. males: NR	Gloneuronal brai n tumors (GNT)	Inclusion: younger than18 years old with morphologically verified gloneuronal brain tumors (GNT).	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment; missing data)
Nossek 2013[40] NRS -Case series n>20 2003 to 2011	Israel - Tel Aviv Medical Center	Patients with intra-axial brain tumors. N=477 Age (mean (SD)): 51.1 (16.3) years No. males: 272, 57%	Intra-axial supratentorial lesion	Inclusion: Patients undergoing AC for tumor resection or open biopsy of an intra-axial supratentorial lesion located within or near eloquent areas.	Intraoperative seizure	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Ogiwara 2010[22] NRS -Case series n>20	USA - Children's Memorial Hospital, Chicago, Illinois	Pediatric patients who underwent surgery for the removal of ganglioglioma N=30	Ganglioglioma	Inclusion: Pediatric patients who underwent surgery for the removal of ganglioglioma and presented with seizures.	Postoperative seizure (Engel) Mortality SAE	Critical (no statistical adjustment for confounders; unblinded

1997 to 2007		Age (mean, range): 8.6 years, 9 months to 16.3 years No. males: 17, 57%				outcome assessment)
Qiu 2014[23] NRS -Cohort study with control group March 2009 to March 2010	China - First Hospital of China Medical University, Liaoning	Patients with intracranial lesions: onset of supratentorial neoplasms manifesting as epilepsy. N=137 Age (mean, range): cases - 37.7, 5-66 years; controls - 37.2, 7-65 years No. males: 74, 54.0%	Supratentorial neoplasms	Inclusion: Patients with intracranial lesions who were admitted for pre-surgical diagnosis and subsequently underwent surgery and presented epilepsy as the initial symptom. Exclusion: Non-tumoral lesions (cavernous angiomas, glial hyperplasia, and pseudotumor, etc.) and metastasis.	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Ramantani 2013[26] NRS -Case series n>20 2001 to 2011	Germany - Epilepsy Centre, University Hospital Freiburg	Children under 3 years undergoing resection for refractory focal epilepsy. N=30 Age (mean, range): 20 months, 5-33.6 months No. males: 17, 56.7%	Varied, etiology predominantly congenital comprising cortical malformations in 28 (93%) cases	Inclusion: Children that underwent resective surgery for intractable structural epilepsy under the age of 3 years at our center.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Ramantani 2018[25] NRS -Case series n>20 2000 to 2014	Germany - University Hospital Freiburg, Freiburg	Children and adolescents who underwent frontal lobe epilepsy surgery. N=75 Age (mean (SD)): 10.0 (4.9) years No. males: 39, 52%	Focal cortical dysplasia (FCD) (n=53, 70%), benign tumors (n=12, 16%)	Inclusion: Children and adolescents who underwent presurgical evaluation in 4 cooperating centers according to the same protocol, underwent frontal lobe epilepsy surgery in 2000 to 2014 in our tertiary epilepsy center, and were followed up >1 year.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

Ravat 2016[27] NRS -Case series n>20 2001 to 2013	India - Comprehensive Epilepsy Care Centre at K.E.M. Hospital, Mumbai	Patients with temporal lobe tumors and drug resistant epilepsy. N=34 Age (mean, range): 20.03 years (6-40) No. males: 19, 55.9%	Temporal lobe tumor	Inclusion: Patients with temporal lobe tumors and drug resistant epilepsy; had undergone surgery at the Comprehensive Epilepsy care Centre at K.E.M. Hospital, Mumbai from 2001 to 2013 and had completed at least 1 year of follow up postoperatively.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Robertson 2019[28] NRS -Case series n>20 2005 to 2014	USA - Boston Children's Hospital	Pediatric patients undergoing brain tumor resection. N=119 Age (median): 11.3 years No. males: 69, 58%	Supratentorial tumor	Inclusion: Diagnosis of a supratentorial tumor, >2 unequivocal seizures, and >6mo follow-up. Exclusion: Isolated cortical dysplasia or posterior fossa tumors, >18 yr of age at the time of surgery	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment; missing data)
Rossini 2017[29] NRS -Cross-sectional study Study dates NR	Italy - Carlo Besta Neurological Institute Foundation and the Claudio Munari Epilepsy Surgery Center at Niguarda Hospital, Milan	Patients with frequent seizures and a long history of drug-resistant focal epilepsy. N=20 Age: NR No. males: NR	Focal cortical dysplasia type 2 (FCD-II) and cryptogenic focal epilepsy	Inclusion: Postsurgical brain tissue obtained from 20 patients with frequent seizures and a long history of drug-resistant focal epilepsy who underwent surgery at the study centers.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
San-Juan 2011[30]	Mexico - National Institute of Neurology, Mexico	Patients with mesial temporal lobe epilepsy who underwent temporal lobe epilepsy surgery.	Unilateral mesial temporal lobe epilepsy (mTLE) with neuroimaging	Inclusion: patients with medically intractable seizures who underwent temporal lobe epilepsy surgery at the study institution during the study period, and who had complete medical	Postoperative seizure (Engel) SAE	Critical (no statistical adjustment for confounders; unblinded

NRS -Case-control study January 2007 to February 2009		N=39 Age (median, range) ECoG group: 36.9, 23 to 47 years; No ECoG group: 33.8, 16 to 51 years. No. males: 12, 30.1%	evidence of hippocampal sclerosis (HS) without other lesions	information and follow up, were included.		outcome assessment)
Santos 2014[31] NRS -Case series n>20 1995 to 2014	Brazil - University of São Paulo	Pediatric patients with focal cortical dysplasia associated with glial and glioneuronal tumors (FCD type IIIb). N=47 Age (mean, range): 11.1, 1–18 years No. males: NR	Glial and glioneuronal tumors	Inclusion: Patients on the authors' personal series from 1995 to 2014 with glial and glioneuronal tumors (FCD type IIIb).	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Shan 2015[32] NRS -Case series n>20 January 2008 to December 2012	China - Xuanwu Hospital, Capital Medical University, Beijing	Patients diagnosed as temporal lobe cavernous malformations (CMs) associated with epilepsy. N=52 Age (mean, range) 26.8, 8-52 years No. males: 31, 59.6%	Temporal lobe cavernous malformations (CMs)	Inclusion: Patients diagnosed with temporal lobe cavernous malformations associated with epilepsy who underwent surgical treatment.	Postoperative seizure (Engel) SAE	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Sommer 2015[33]	Germany - University Hospital Erlangen	Patients with cerebral gangliogliomas.	Gangliogliomas	Inclusion: Adult patients with gangliogliomas who underwent surgery	Postoperative seizure (Engel)	Critical (no statistical adjustment for

NRS -Case series n>20 December 2002 to April 2013		N=69 Age (median (SD)): 28.5 (15.4) years No. males: 38, 55%		for drug-resistant epilepsy at the study institution.	Mortality SAE	confounders; unblinded outcome assessment)
Southwell 2012[5] NRS -Case series n>20 1987 to 2008	USA - University of California, San Francisco	Pediatric and adult patients with gangliogliomas and seizures. N=49 Age (median, range): 25, 3-75 years No. males: 24, 49%	Ganglioglioma	Inclusion: Underwent resection of gangliogliomas histologically confirmed by World Health Organization criteria, and history of seizures.	Postoperative seizure (ILAE) SAE	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Sugano 2007[34] NRS -Case series n>20 1989 to 2002	Japan - Tokyo Metropolitan Neurological Hospital	Patients who were surgically treated for medically intractable epilepsy caused by temporal-lobe benign mass lesions. N=35 Age (mean (SD)): 21.7 (12.6) years No. males: 19, 54%	Temporal-lobe benign mass lesions	Inclusion: Patients who were surgically treated for medically intractable epilepsy caused by temporal-lobe benign mass lesions during the study period.	Postoperative seizure (no classification) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Terra 2014[35] NRS -Case series n>20	Brazil - Centro de Cirurgia de Epilepsia (CIREP), Sao Paulo	Children with intractable epilepsy due to focal cortical dysplasia. N=78	Focal cortical dysplasia	Inclusion: Under 18 years of age with diagnosis of intractable epilepsy due to focal cortical dysplasia who underwent surgery.	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders; unblinded

January 1996 to January 2012		Age (mean (SD)): 8.52 (4.99) years No. males: 38, 48.7%		Exclusion: Diagnosis of hemimegalencephaly.		outcome assessment)
von Lehe 2009[36] NRS -Case series n>20 1989 to September 2007	Germany - Bonn Epilepsy Surgery Program	Patients who underwent epilepsy surgery for a lesion involving the insular region. N=24 Age (mean, range): 27, 1–62 years No. males: 9, 37.5%	Insular lesions	Inclusion: Patients who suffered from medically intractable epilepsy originating from the insular cortex and underwent resective epilepsy surgery.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Yao 2018[37] NRS -Case series n>20 January 2002 to March 2015	China - The First Affiliated Hospital of Fujian Medical University, Fuzhou	Adult patients with low-grade gliomas. N=108 Age (mean (SD)): ECoG: 27.0 (14.2); no ECoG: 25.4 (14.8) years No. males: 64, 59.3%	Low-grade glioma	Inclusion: Adult patients with low-grade glioma (located at the frontal, temporal, or parietal lobes) presenting with refractory seizures who underwent surgery at our institute. Exclusion: Patients without complete resection of tumor.	Postoperative seizure (Engel)	Critical (statistical adjustment for confounders but no details; unblinded outcome assessment)
Zhang 2022[38] NRS -Case series n>20 January 2014 to	China - Xiangya Hospital, Central South University, Hunan	Patients with frontal diffuse low-grade gliomas (DLGG)-related epilepsy. N=115 Age (median, range): 37, 5.50 to 70 years No. males: 64, 55.7%	Frontal diffuse low-grade gliomas	Inclusion: Diagnosis of DLGG (WHO grade II astrocytoma or oligodendroglioma) based on postoperative pathological examination; DLGG located in the frontal lobe; preoperative epilepsy associated with DLGG; underwent follow-up of more than 12 months after surgery.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

January 2021				Exclusion: Postoperative pathological diagnosis that was not DLGG; did not have preoperative epilepsy, or epilepsy was found to be not associated with the DLGG after preoperative evaluation; had a DLGG that involved brain tissue beyond the frontal lobes; and had a follow-up of less than 12 months.		
Zheng 2022[39] NRS -Case series n>20 January 2013 to January 2020	China - Zhejiang University School of Medicine Second Affiliated Hospital, Hangzhou	Patients with low-grade epilepsy-associated neuroepithelial tumor (LEAT). N= 61 Age (median): 24.0 years No. males: 31, 50.8%	Low-grade epilepsy-associated neuroepithelial tumor (LEAT)	Inclusion: Tumor located solely in the temporal lobe without extending into other lobes, WHO grade I or II verified by pathological examination, and follow-up of at least 12 months. Exclusion: Extratemporal lobe LEAT, previous brain surgery or MRI-verified findings of other brain lesions such as cavernous malformation.	Postoperative seizure (Engel) Mortality SAE	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

NR: not reported; NRS: non-randomized study; RCT: randomized controlled trial; ROB: risk of bias; SAE: serious adverse events

PICO 2: Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?

Study details	Country – setting/location	Population	Type of lesion/tumor	Inclusion/exclusion criteria	Outcomes	ROB score (ROBINS I)
Alarcon 1997 NRS - Case series n>20 Study dates NR	Spain/UK - Unclear setting	Adult and pediatric patients who underwent temporal lobe surgery for medically intractable complex partial or secondarily generalized seizures. N=42 Age (mean (range)): 26 (4-58) years No. males: 27, 64.3%	Varied	Inclusion: Underwent resective temporal lobe surgery for medically intractable complex partial or secondarily generalized seizures.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Burkholder 2014 NRS - Case series n>20 January 1990 to October 2010	USA - Mayo Clinic Epilepsy Surgery Database	Adult and pediatric patients with temporal lobe epilepsy who underwent standard amygdalohippocampectomy. N=87 Age (median (IQR)): 34 (25-43) years No. males: 31, 35.6%	Temporal lobe - varied pathology	Inclusion: Medically resistant TLE, normal MRI findings, no prior neurologic surgery, standardized ECoG at the time of surgery, and at least 12 months of post-operative follow-up Excluded: Patients who underwent surgery without standard intraoperative ECoG, regardless of other testing; patients were excluded if MRI demonstrated any hippocampal atrophy or signal change, tumor, encephalomalacia, cortical dysplasia, or vascular abnormalities other than noncortical developmental venous anomalies.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Cascino 1995 NRS - Case series n>20	USA - Mayo Clinic, Rochester, Minnesota	Patients with intractable non-lesional temporal lobe epilepsy (NLTLE) N=165	Intractable non-lesional temporal lobe epilepsy (NLTLE)	Inclusion: Left hemisphere language dominant patients with NLTLE who underwent an anterior temporal lobectomy Exclusion: Less than 1 year follow up	Postoperative seizure (% reduction)	Critical (no statistical adjustment for confounders; unblinded

1988 to 1993		Age (mean (SD)): 32.5 (10.1) years No. males: NR				outcome assessment)
Chang 2010 NRS - Case series n>20 January 1990 to April 2006	USA - University of California, San Francisco	Adult and pediatric patients who underwent resection of dysembryoplastic neuroepithelial tumors (DNETs) N=50 Age (median (range)): 21 (4–46) years No. males: 33, 66%	Dysembryoplastic neuroepithelial tumors (DNETs)	Inclusion: Patients who underwent resection of DNETs were included if they had not undergone any prior resection for their tumor, or if only biopsies were performed as part of a diagnostic workup. All included patients had histologically confirmed DNETs according to WHO criteria.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Chang 2011 NRS - Case series n>20 February 1990 to September 2009	USA - University of California, San Francisco	Adult and pediatric patients with malformations of cortical development (MCDs) who underwent resective surgery for medically refractory epilepsy N=143 Age (median (range)): 21 (0-58) years No. males: 74, 51.7%	Malformations of cortical development (hemimegalencephaly, polymicrogyria, cortical dysplasia associated with mesial temporal sclerosis, and DNET)	Inclusion: Patients with gross macroscopic findings of hemimegalencephaly, polymicrogyria, cortical dysplasia associated with mesial temporal sclerosis, and DNET were included when histopathology showed evidence of cortical dysgenesis. Exclusion: Postoperative diagnosis of tuberous sclerosis, because this is thought to be a separate entity from MCD.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Cho 2005 NRS - Case series n>20 October 1997 to October 2000	Taiwan - China Medical University Hospital, Taichung	Adult and pediatric patients with medically intractable epilepsy detected by MRI. N=46 Age (mean (range)): 38.1 (5 - 72) years No. males: 28, 61%	Brain tumors (23), gliosis (11), cavernous hemangioma (7), arachnoid cyst (3), arteriovenous malformation (AVM) (2).	Inclusion: Patients with medically intractable epilepsy detected by MRI.	Postoperative seizure (Engel) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

El Tahry 2016 NRS - Case series n>20 January 2003 to December 2013	Belgium - Saint-Luc hospital, Universite Catholique de Louvain (UCL), Brussels	Adult and pediatric patients who underwent epilepsy surgery with intra-operative ECoG for intractable epilepsy. N=94 Age (median (range)): 27 (3-64) years No. males: 58, 62%	Lesional (n=71, 76%), non-lesional (n=23, 24%)	Inclusion: (1) Epilepsy surgery for intractable epilepsy, (2) intra-operative ECoG data available, (3) focal or pluri-focal epilepsy based on corroborating evidence from non-invasive and invasive video-EEG data (if performed), MRI and PET scan.(4) lesional or non-lesional epilepsy defined by the absence or presence of a causal lesion on MRI (5) Follow-up of at least 1 year. Exclusion: (1) Epileptic encephalopathy in which epileptiform activity was believed to contribute to severe cognitive and behavioral disturbances, (2) follow-up <1 year.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Greiner 2016 NRS - Case series n>20 June 2008 to May 2014	USA - Cincinnati Children's Hospital Medical Center	Children with focal resections (corticectomy and/or lobectomy) who had post-resection ECoG performed on the margins of resection. N=124 Age (median (range)): 11.2 (0.5-20) years No. males: NR	Varied	Inclusion: Children who had focal resections (corticectomy and/or lobectomy) from June 1, 2008 to May 1, 2014.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Grewal 2020 NRS - Case series n>20 1990 to 2016	USA - Mayo Clinic, Rochester, MN	Adult and pediatric patients with medically resistant MRI-negative temporal lobe epilepsy (TLE). N=127 Age (mean (SD)): 35.7 (12.6) years No. males: 46, 36%	Varied	Inclusion: All adult and pediatric patients with medically resistant MRI-negative TLE undergoing temporal lobectomy in which standardized intraoperative ECoG was used were included. Exclusion: Exclusion criteria included presence of a radiologically identified lesion or evidence of mesial temporal sclerosis	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

				(MTS) on MRI obtained according to a seizure protocol, and any prior neurological surgery.		
Jennum 1993 NRS - Case series n>20 January 1983 to January 1990	Denmark / USA - Setting unclear	Adult and pediatric patients with medically intractable epilepsy. N=64 Age median (range) 24 (8-52) years No. males: 45, 70.3%	*	Inclusion: Patients with medically intractable epilepsy who underwent a tailored temporal or cortical resection and had a minimum follow-up of one year. Exclusion: Less than 1 year follow up time.	Postoperative seizure (No formal classification)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Kuang 2024 NRS - Case series n>20 October 2010 to April 2023	China - Three epilepsy centers in Beijing	Adult and pediatric patients with low-grade epilepsy-associated brain tumors (LEATs) who underwent resective surgery. N=111 Age (mean (SD)): 16.85 (15.69), range 0.3-48 years No. males: 69, 62.2%	Low-grade epilepsy-associated brain tumors (LEATs)	Inclusion: (1) Patients with lesion-associated epilepsy; (2) postoperative pathology was diagnosed as LEAT and tumor were classified as grade WHO I or grade WHO II; (3) children or adults with at least 1-year follow-up. Exclusion: (1) Subjects undergoing other neurosurgical operations for reasons other than epilepsy; (2) patients without outcome of seizure control at 1-year follow-up; (3) cases with incomplete clinical data.	Postoperative seizure (ILAE)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
McKhann 2000 NRS - Case series n>20 1991 to 1995	USA - University of Washington, Seattle	Adult and pediatric patients with medically refractory mesial temporal lobe epilepsy (TLE). N=140 Age (mean (range)): 32 (7 to 59) years No. males: 68, 49%	Mesial temporal sclerosis with neuronal loss (MTS group) or mild gliosis without neuronal loss (non-MTS group)	Inclusion: Patients with medically intractable complex partial seizures of medial temporal lobe origin, without evidence of either a mass lesion or developmental abnormality, who were surgically treated within a 5-year period (1991–1995) at the University of Washington. Patients with mesial temporal lobe sclerosis (MTS) as well as individuals with minimal hippocampal	Postoperative seizure (% reduction)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

				pathological findings (non-MTS group) were included. Exclusion: Patients were excluded if a preoperative MRI or postoperative pathological study documented the presence of one of the following pathological lesions: intrinsic brain tumor, vascular malformation, hamartoma, or cortical dysgenesis.		
Rassi-Neto 1999 NRS - Case series n>20 Study dates NR	Brazil - Federal University of Sao Paulo	Adult and pediatric patients with intractable epilepsy. N= 21 Age (mean (range)): 27.3 (9 to 56) years No. males: 11, 52%	Varied	Inclusion: Patients with epileptic seizures and intracerebral lesions, diagnosed through cranial computerized tomography (CT), referred to us from the Sector for Investigation and Treatment of Epilepsy, Department of Neurology and Neurosurgery of the Federal University of Sao Paulo, Brazil.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Schiller 2000 NRS - Case series n>20 1989 to 1993	USA - Mayo Clinic Rochester	Adult and pediatric patients who underwent surgical treatment for intractable partial epilepsy. N=210 Age (mean (range)): 31.9 (9 to 55) years No. males: 11, 52%	Varied	Inclusion: Patients who were rendered seizure and aura-free for 1 year or more after surgical treatment for intractable partial epilepsy. Exclusion: Patients with isolated auras.	Postoperative seizure (No formal classification)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Schwartz 1997 NRS - Case series n>20 1992 to 1994	USA - The Neurological Institute of New York	Adult and pediatric patients with medial temporal lobe epilepsy. N=29 Age (mean (range)): 32 (8-52) years No. males: 18, 62.1%	Medial temporal sclerosis	Inclusion: 1) Medically intractable complex partial seizures with or without secondary generalization; 2) scalp video-electroencephalographic recordings that demonstrated consistent unilateral temporal lobe ictal onset and no extratemporal interictal spikes; 3) videotape documentation of ictal semiology consistent with unilateral	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

				mesial temporal lobe seizures; 4) T1weighted, T2-weighted, and short-tau inversion recovery MRI sequences showing unilateral MTS, defined as hippocampal volume loss and/or increased signal intensity (7) but no other structural lesion such as tumor, cavernous malformation, or cortical dysplasia. Patients with independent bitemporal interictal epileptiform abnormalities were not excluded if they met all other criteria.		
Shih 1994 NRS - Case series n>20 August 1987 to July 1992	Taiwan _ Veterans General Hospital, Taipei	Adults with intractable complex partial seizure (CPS) of the temporal lobe region who received anterior temporal lobectomy. N=30 Age: NR No. males: NR	Not specified	Inclusion: Uncontrolled seizures refractory to adequate trials of appropriate anticonvulsants for at least 2 years; 2) partial seizures; 3) seizures which significantly interfered with their daily activity; 4) no evidence of progressive neurological deficits, mental retardation or psychiatric problems; 5) sufficient motivation to complete the evaluation.	Postoperative seizure (No formal classification) Mortality	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Stepanenko 2009 NRS - Case series n>20 Study dates NR	Russia - NN Burdenko Institute of Neurosurgery, Moscow	Patients with drug-resistant temporal epilepsy N=29 Age (mean (SD)): 24.5 (7.2) No. males: 24, 49%	Patients with small (<3 cm in diameter) intracerebral tumors of extrahippocampal location without progressive growth (n=14), focal cortical dysplasia (n=8), and hippocampal sclerosis (n=4).	Patients with drug resistant temporal epilepsy.	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)

Stepanenko 2013 NRS - Case series n>20 May 2008 to June 2010	Russia - N.N. Burdenko Neurosurgery Institute, Moscow	Patients with symptomatic epilepsy due to isolated forms of focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD. N=25 Age (median (range)): 24 (16-39) years No. males: 11, 44%	Focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD	Inclusion: Patients with symptomatic epilepsy due to isolated forms of focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD, all of whom underwent tailored surgical procedures under intraoperative electrocorticography.	Postoperative seizure (Engel) Mortality Serious Adverse Events	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Tran 1995 NRS - Case series n>20 1991 to 1993	USA - Yale University School of Medicine, New Haven, CT	Adult and pediatric patients with nonlesional medial temporal lobe epilepsy. N=47 Age (mean (range)): 31 (14 to 50) years No. males: 26, 55%	Varied nonlesional	Inclusion: Patients with medically intractable complex partial seizures of medial temporal lobe origin and no evidence of a space occupying lesion, who underwent anteromedial temporal lobectomy and had intraoperative ECoG. Exclusion: Patients with evidence of brain tumor, vascular malformation, or cortical dysgenesis on head MRI were excluded.	Postoperative seizure (No formal classification)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Wray 2012 NRS - Case series n>20 October 2003 to October 2009	USA - Seattle Children's Hospital	Pediatric patients with epileptic seizures. N=52 Age (mean (range)): 9.3 years (3 months to 17.4 years) No. males: 24, 46.2%	67% were temporal lesions	Inclusion: Pediatric patients who had undergone epilepsy surgery and post-ECoG. Exclusion: Patients who did not have adequate follow up (1 year).	Postoperative seizure (Engel)	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Wu 2010 NRS - Case series n>20	USA - University of California, Los Angeles (UCLA) Pediatric Epilepsy Surgery Program	Children with medically refractory epilepsy N=30	Majority had extratemporal lesions	Inclusion: Children with medically refractory epilepsy who underwent surgical resections at UCLA	Postoperative seizure (No formal classification)	Critical (no statistical adjustment for confounders; unblinded

August 2007 to September 2008		Age (mean (SD)): 9.1 (6.7); range 8 months to 20 years No. males: 15, 50%				outcome assessment)

PICO 3: Do psychological and psychiatric outcomes differ among patients undergoing awake vs. Asleep intraoperative ECoG recording?

Study details	Country – setting/location	Population	Type of lesion/tumor	Inclusion/exclusion criteria	Outcomes	ROB score (ROBINS I)
Conte 2006 NRS – Case series n>20 July 2005 to July 2006	Italy – University of Milan	Adults undergoing tumor resection with functional brain mapping N=37 Age (median (range)): Awake group 40 (22-53) years; Asleep group 51 (23-76) years No. males: 20, 54%	Not specified	Inclusion: Patients admitted between July 2005 and June 2006 for tumor resection who underwent surgery with intraoperative cortical and subcortical functional brain mapping. The awake group included patients who required language testing and the asleep group those who underwent motor testing only.	Intraoperative seizure	Critical (no statistical adjustment for confounders; unblinded outcome assessment)
Lettieri 2023 NRS – Case series n>20 January 2007 to May 2018	Italy – University Hospital Udine	Adults presenting a newly diagnosed supratentorial low-grade gliomas (LGGs) with seizure N=155 Age (median (range)): 37 (18-73) years No. males: 96, 61.9%	Supratentorial low-grade gliomas	Inclusion: 1. Age ≥18 years 2. Preoperative MRI suggestive of supratentorial LGG 3. One or more epileptic seizures as the initial presentation of the glioma 4. No previous surgery 5. No preoperative chemotherapy or radiotherapy 6. Objective evaluation of extent of resection on MRI images in Digital Imaging and Communications in Medicine format based on T2-weighted MRI sequences	Intraoperative seizure	Critical (statistical adjustment for confounders but no details provided; unblinded outcome assessment)
Morsy 2021	Egypt - Zagazig University, Alsharkia	Adults with hemispheric perirolandic glioma	Hemispheric perirolandic glioma	Inclusion: patients with hemispheric perirolandic glioma (3 cm anterior or posterior to the motor	Intraoperative seizure	Critical (no statistical adjustment for

NRS – Case series n>20 2014 to 2019		N=64 Age, mean (SD): Awake group 42.7 (14.5) years; Asleep group 49.5 (15.5) years No. males: 36, 56%		cortex) who underwent surgical resection using intraoperative cortical and subcortical mapping techniques either under awake craniotomy or craniotomy under general anesthesia between 2014 and 2019 by the same neurosurgery and anesthesia teams. Patients with the following inclusion criteria were operated under awake craniotomy: (1) Age >18 and <70 years without major cardiopulmonary co-morbidities; (2) Fluent in speaking and understanding without preoperative cognitive impairment (mini mental state examination more than 24); (3) Do not have severe language deficits (greater than 30% of naming errors) or motor deficits less than antigravity motor function. (4) Do not show severe anxiety or emotional instability (The State-Trait Anxiety Inventory score less than 55); (5) Patient is accepting and understanding the technique and the type of procedure. Patients who did not meet these criteria were operated under general anesthesia.	Postoperative seizure SAE	confounders; unblinded outcome assessment)

Appendix 3: Forest plots with meta-analyses

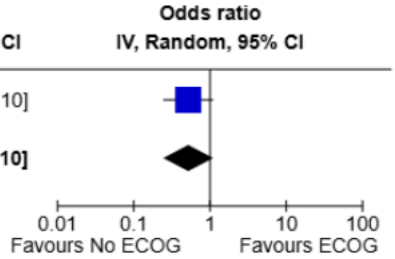
PICO 1: Intraoperative electrocorticography (ECoG), compared to no intraoperative ECoG

1. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up ≤2 weeks

Study or Subgroup	ECOG Events	ECOG Total	No ECOG Events	No ECOG Total	Weight	Odds ratio IV, Random, 95% CI
Feyissa 2023	26	49	48	70	100.0%	0.52 [0.24 , 1.10]
Total		**49**		**70**	**100.0%**	**0.52 [0.24 , 1.10]**
Total events:	26		48			

Test for overall effect: Z = 1.71 (P = 0.09)

Heterogeneity: Not applicable

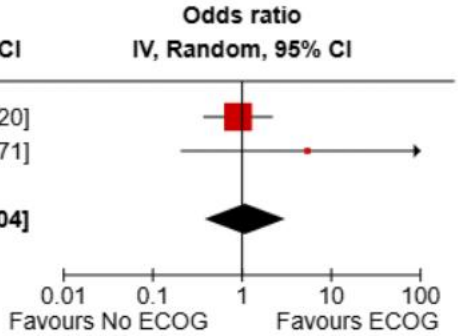


2. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >2 weeks to ≤6 months)

Study or Subgroup	log[OR]	SE	Weight	Odds ratio IV, Random, 95% CI
Robertson 2019	-0.105361	0.45709	90.2%	0.90 [0.37 , 2.20]
Sugano 2007	1.686399	1.670662	9.8%	5.40 [0.20 , 142.71]
Total (Wald[a])			**100.0%**	**1.07 [0.38 , 3.04]**

Test for overall effect: Z = 0.13 (P = 0.90)

Heterogeneity: Tau² (REML[b]) = 0.11; Chi² = 1.07, df = 1 (P = 0.30); I² = 7%



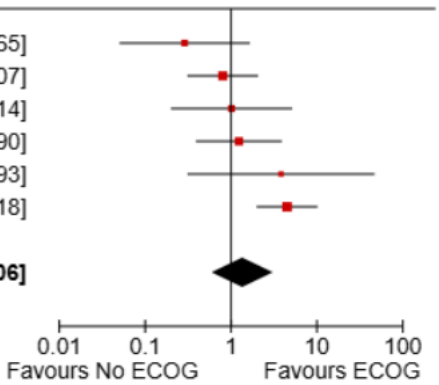
Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

3. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >6 months to ≤1 year) (GIV)

Study or Subgroup	log[OR]	SE	Weight	Odds ratio IV, Random, 95% CI
Chang 2010	-1.244795	0.891939	12.9%	0.29 [0.05 , 1.65]
Robertson 2019	-0.223144	0.483968	22.0%	0.80 [0.31 , 2.07]
Kuang 2024	0.012423	0.829063	14.0%	1.01 [0.20 , 5.14]
Gelinas 2011	0.210492	0.587277	19.3%	1.23 [0.39 , 3.90]
Sugano 2007	1.339774	1.28005	8.0%	3.82 [0.31 , 46.93]
Yao 2018	1.501807	0.417553	23.8%	4.49 [1.98 , 10.18]
Total (Wald[a])			**100.0%**	**1.34 [0.59 , 3.06]**



Test for overall effect: Z = 0.71 (P = 0.48)

Heterogeneity: Tau² (REML[b]) = 0.57; Chi² = 12.81, df = 5 (P = 0.03); I² = 58%

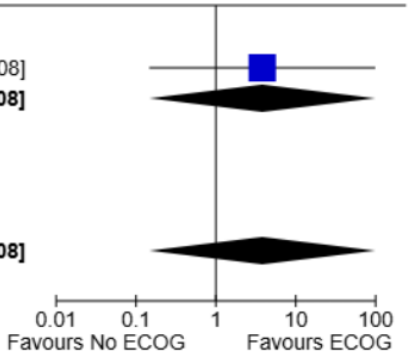
Footnotes

[a]CI calculated by Wald-type method.

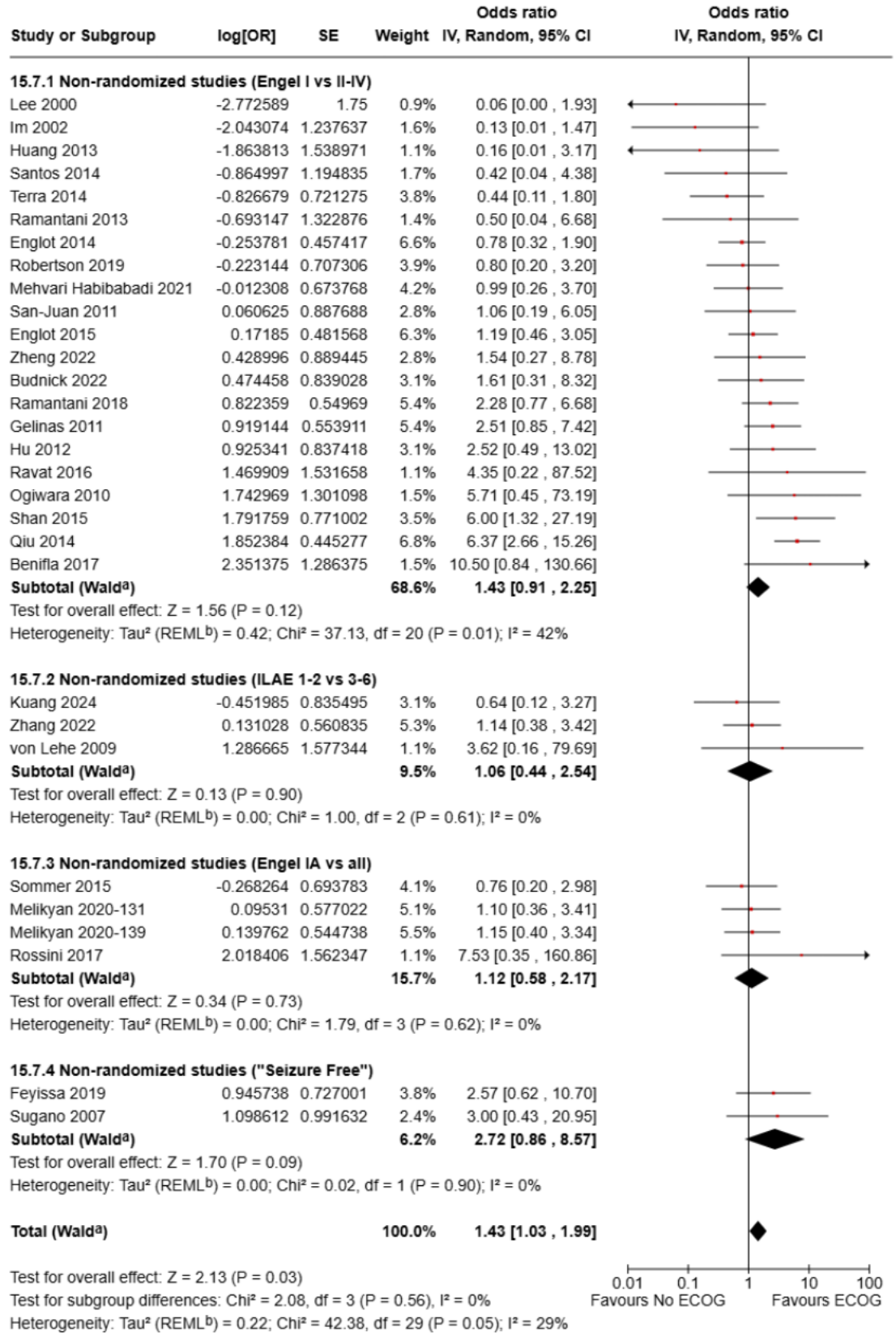
[b]Tau² calculated by Restricted Maximum-Likelihood method.

4. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted RCT) (follow-up >1 year)

Study or Subgroup	ECOG Events	ECOG Total	No ECOG Events	No ECOG Total	Weight	Odds ratio IV, Random, 95% CI
15.5.1 RCT (Engel I)						
Rajeev 2024	23	23	18	19	100.0%	3.81 [0.15 , 99.08]
Subtotal		**23**		**19**	**100.0%**	**3.81 [0.15 , 99.08]**
Total events:	23		18			
Test for overall effect: Z = 0.80 (P = 0.42)						
Heterogeneity: Not applicable						
Total		**23**		**19**	**100.0%**	**3.81 [0.15 , 99.08]**
Total events:	23		18			
Test for overall effect: Z = 0.80 (P = 0.42)						
Test for subgroup differences: Not applicable						
Heterogeneity: Not applicable						



5. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >1 year)



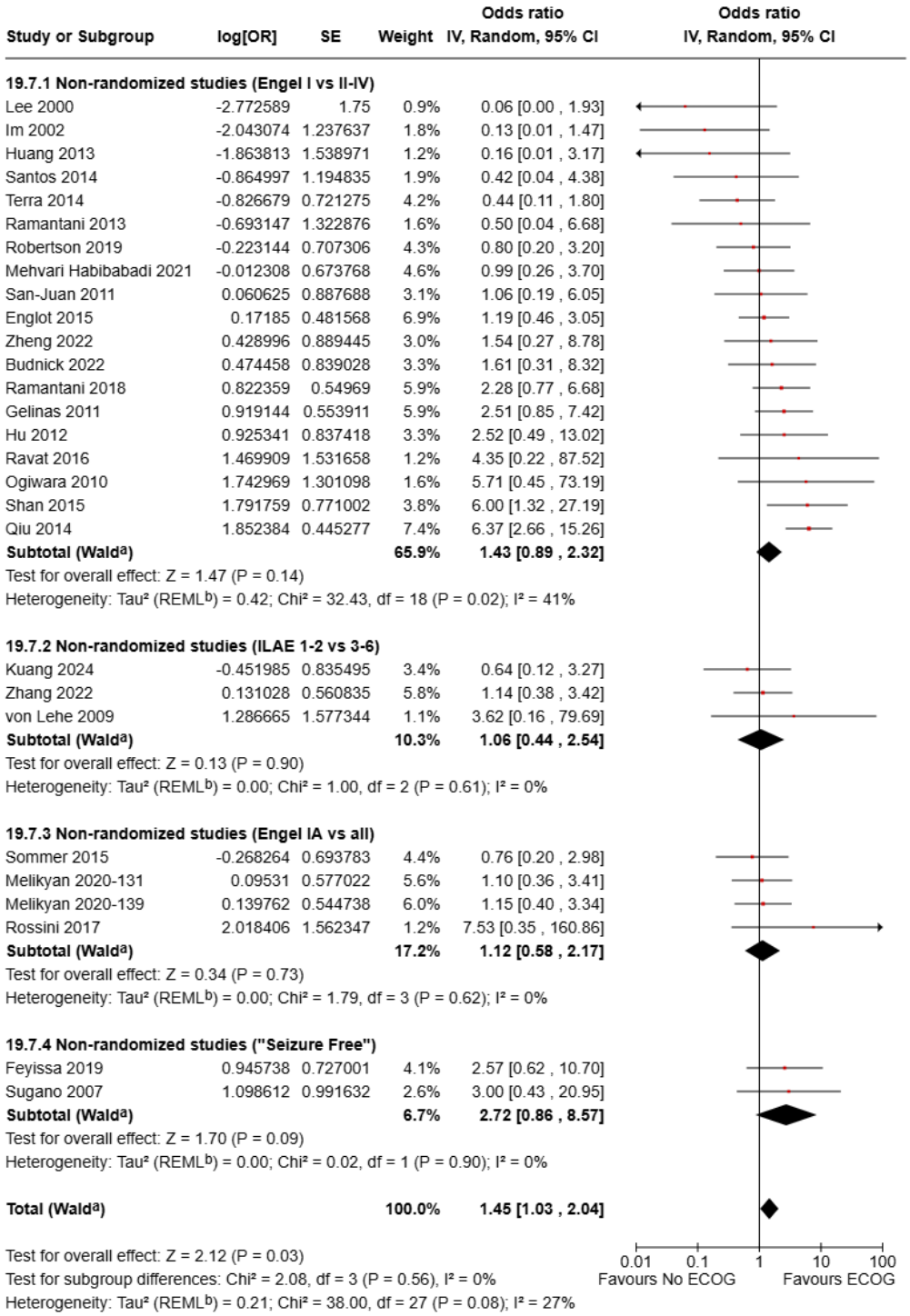
Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

5.a Subgroup – Lesion

Postoperative Seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year) (GIV)



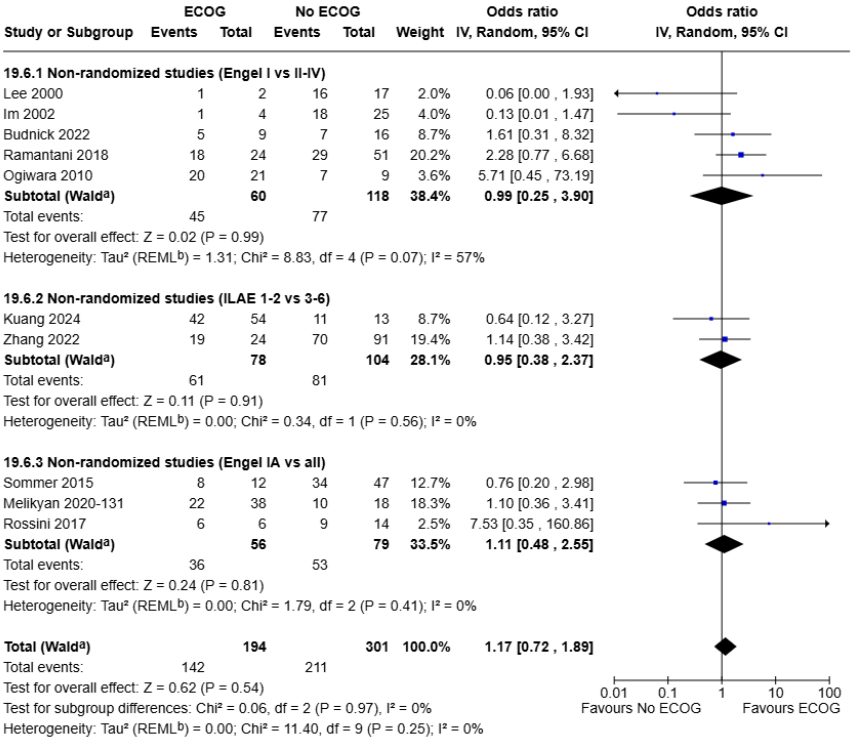
Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

5.b Subgroup – Low grade tumor

Postoperative Seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year)



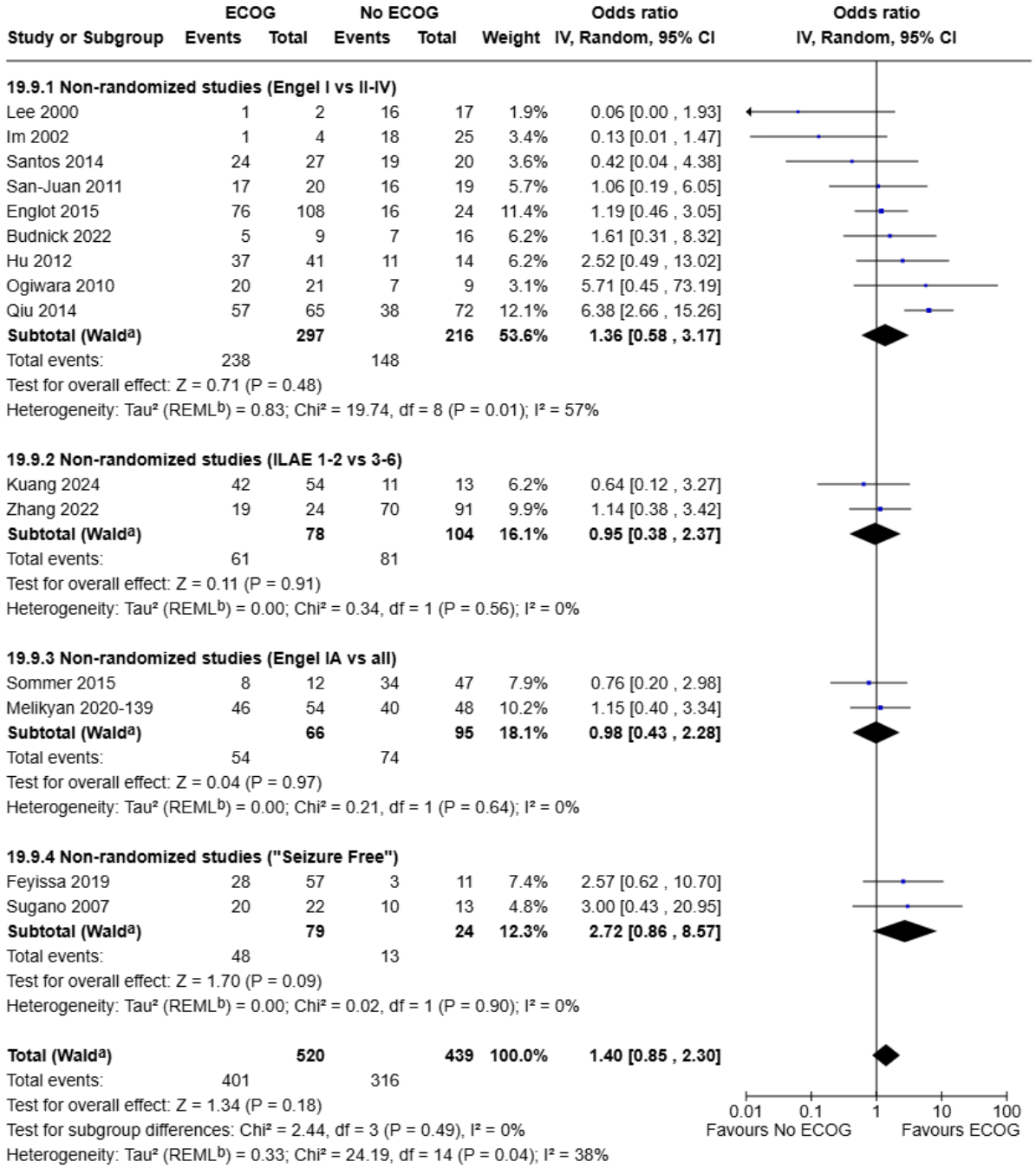
Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

5.c Subgroup – Non-genetic

Postoperative Seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year)



Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

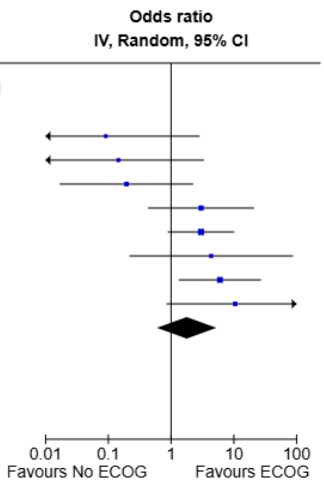
5.d Subgroup – Temporal location

Post-operative seizure - Engel I vs II-IV [no other seizure free categories with data] (Unadjusted) (follow-up >1 year)

Study or Subgroup	ECOG Events	ECOG Total	No ECOG Events	No ECOG Total	Weight	Odds ratio IV, Random, 95% CI
19.1.1 Engel I vs II-IV [no other classifications available] (all time frames - range 1 year to 5 years) Unadjusted						
Ogiwara 2010	15	15	3	3		Not estimable
Lee 2000	1	2	11	12	7.3%	0.09 [0.00 , 2.85]
Santos 2014	10	12	14	14	8.4%	0.14 [0.01 , 3.34]
Im 2002	1	4	12	19	11.5%	0.19 [0.02 , 2.25]
Sugano 2007	20	22	10	13	14.6%	3.00 [0.43 , 20.95]
Yao 2018	18	30	6	18	20.3%	3.00 [0.88 , 10.18]
Ravat 2016	8	8	21	26	8.9%	4.35 [0.22 , 87.52]
Shan 2015	36	41	6	11	17.9%	6.00 [1.32 , 27.19]
Benifla 2017	14	15	4	7	11.1%	10.50 [0.84 , 130.66]
Subtotal (Wald[a])		**149**		**123**	**100.0%**	**1.77 [0.59 , 5.27]**
Total events:	123		87			

Test for overall effect: Z = 1.02 (P = 0.31)
Heterogeneity: Tau² (REML[b]) = 1.14; Chi² = 13.64, df = 7 (P = 0.06); I² = 50%

Test for subgroup differences: Not applicable



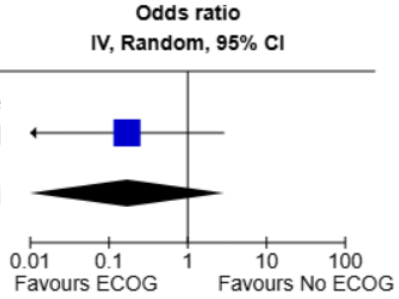
Footnotes
[a]CI calculated by Wald-type method.
[b]Tau² calculated by Restricted Maximum-Likelihood method.

6. Mortality (follow-up <2 weeks post-op)

Study or Subgroup	ECOG Events	ECOG Total	No ECOG Events	No ECOG Total	Weight	Odds ratio IV, Random, 95% CI
Qiu 2014	0	65	0	72		Not estimable
Terra 2014	1	66	1	12	100.0%	0.17 [0.01 , 2.91]
Total		**131**		**84**	**100.0%**	**0.17 [0.01 , 2.91]**
Total events:	1		1			

Test for overall effect: Z = 1.22 (P = 0.22)

Heterogeneity: Not applicable

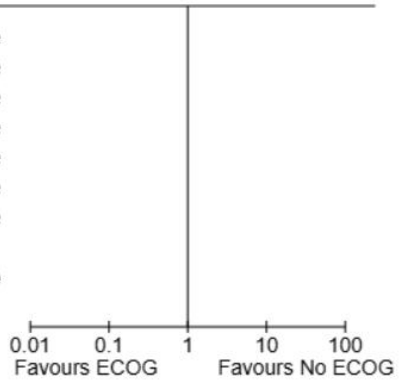


7. Mortality (follow-up ≥2 years post-op)

Study or Subgroup	ECOG Events	ECOG Total	No ECOG Events	No ECOG Total	Weight	Odds ratio IV, Random, 95% CI
Benifla 2017	0	15	0	7		Not estimable
He 2022	0	16	0	37		Not estimable
Hu 2012	0	41	0	14		Not estimable
Ogiwara 2010	0	21	0	9		Not estimable
Sommer 2015	0	12	0	47		Not estimable
Sugano 2007	0	22	0	13		Not estimable
Zheng 2022	0	51	0	9		Not estimable
Total		**178**		**136**		**Not estimable**
Total events:	0		0			

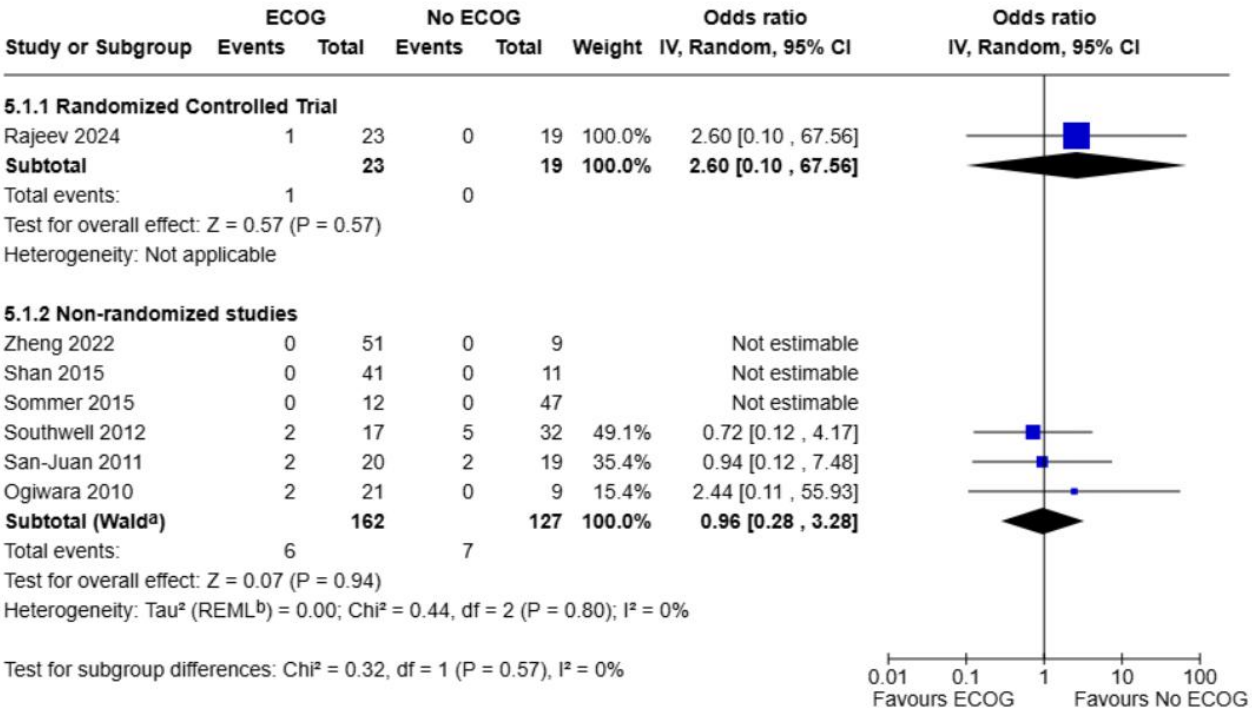
Test for overall effect: Not applicable

Heterogeneity: Not applicable



8. Serious Adverse Event (any) (unadjusted RCT) (follow-up ≥2 years post-op) (see #12)

9. Serious Adverse Event (any) (unadjusted) (follow-up ≥2 years post-op)

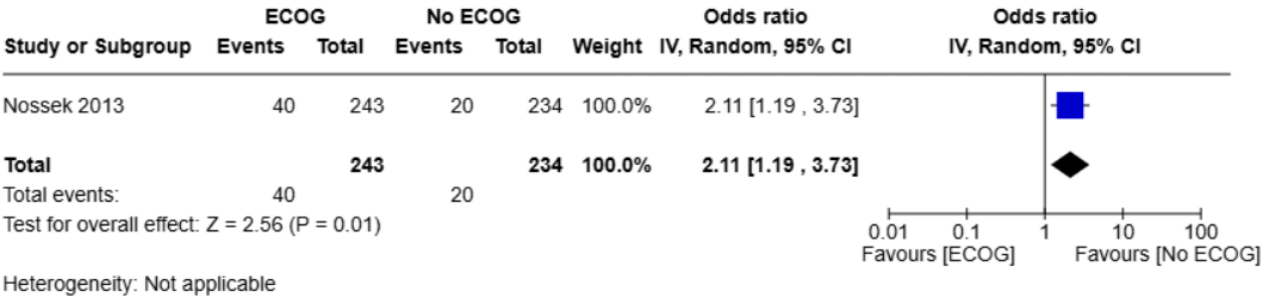


Footnotes

[a]CI calculated by Wald-type method.

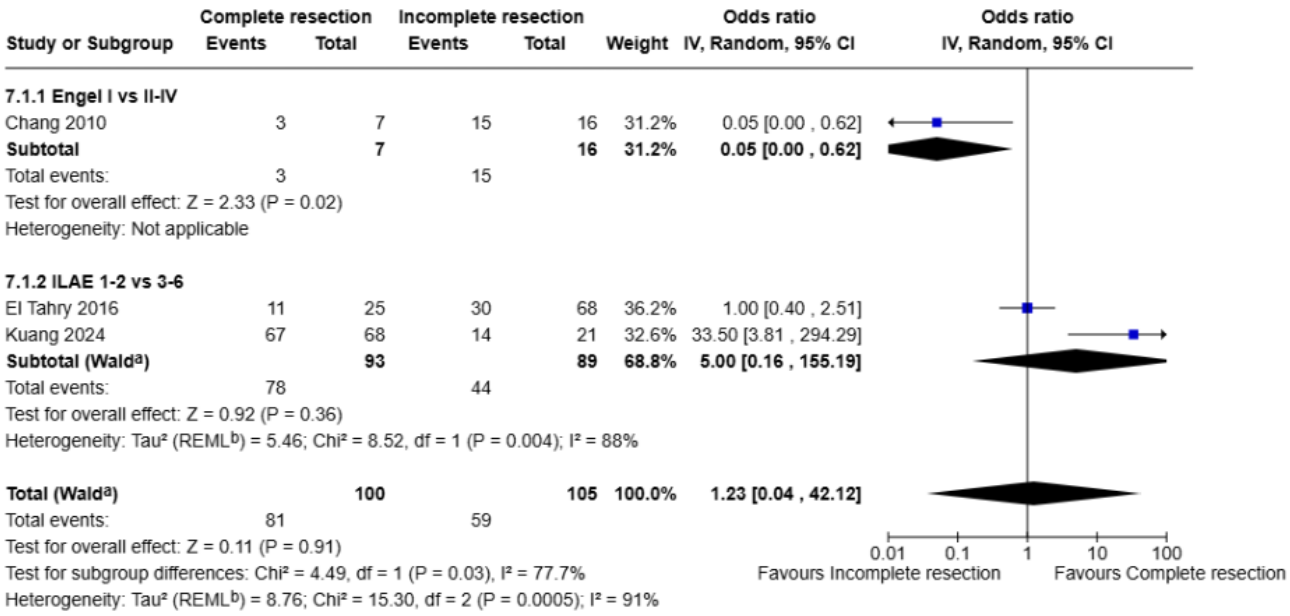
[b]Tau² calculated by Restricted Maximum-Likelihood method.

10. Intra-operative seizure (unadjusted) (follow-up mean 3.7 years post-op)



PICO 2: Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?

1. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >6 months to ≤1 year

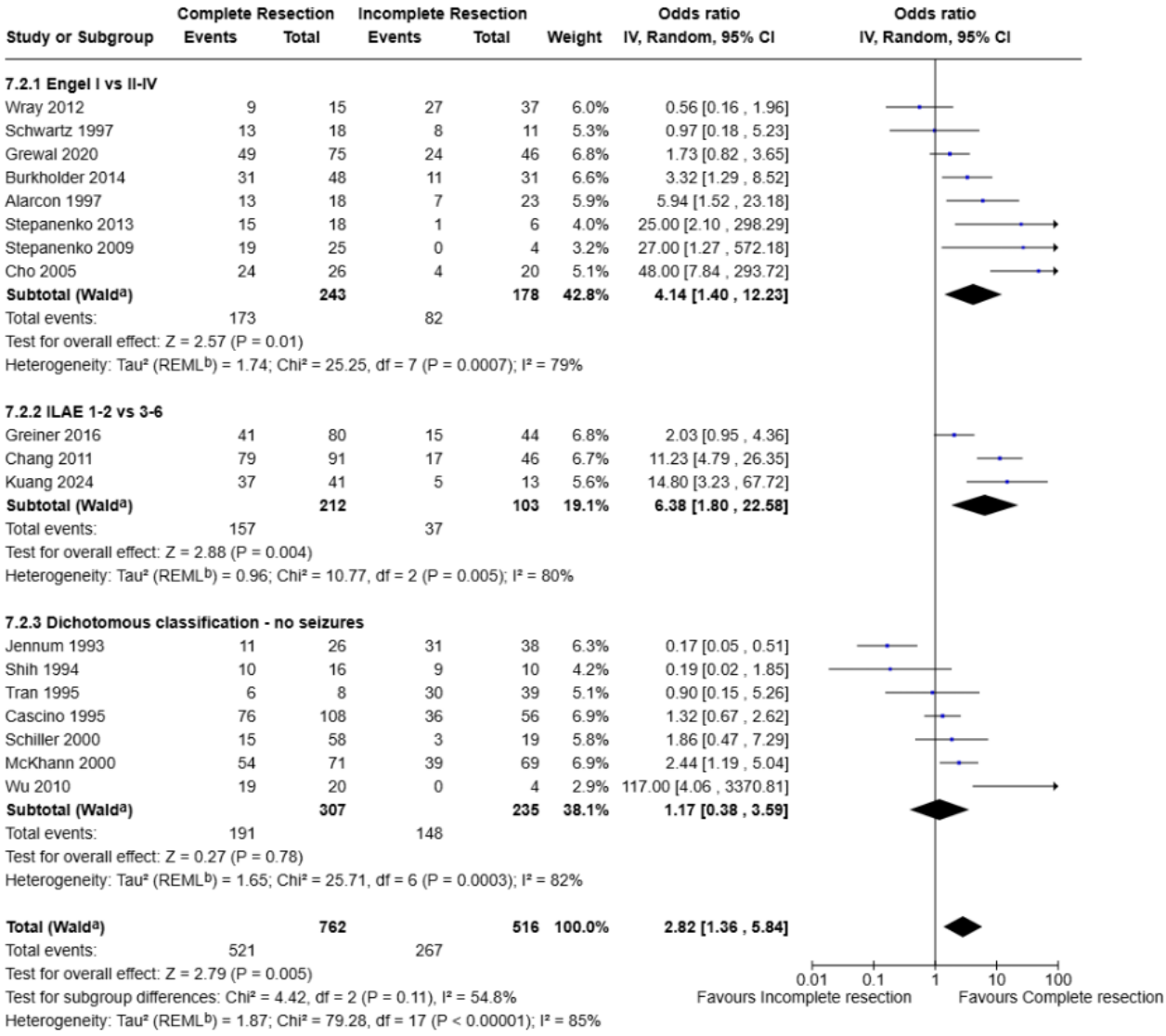


Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

2. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year

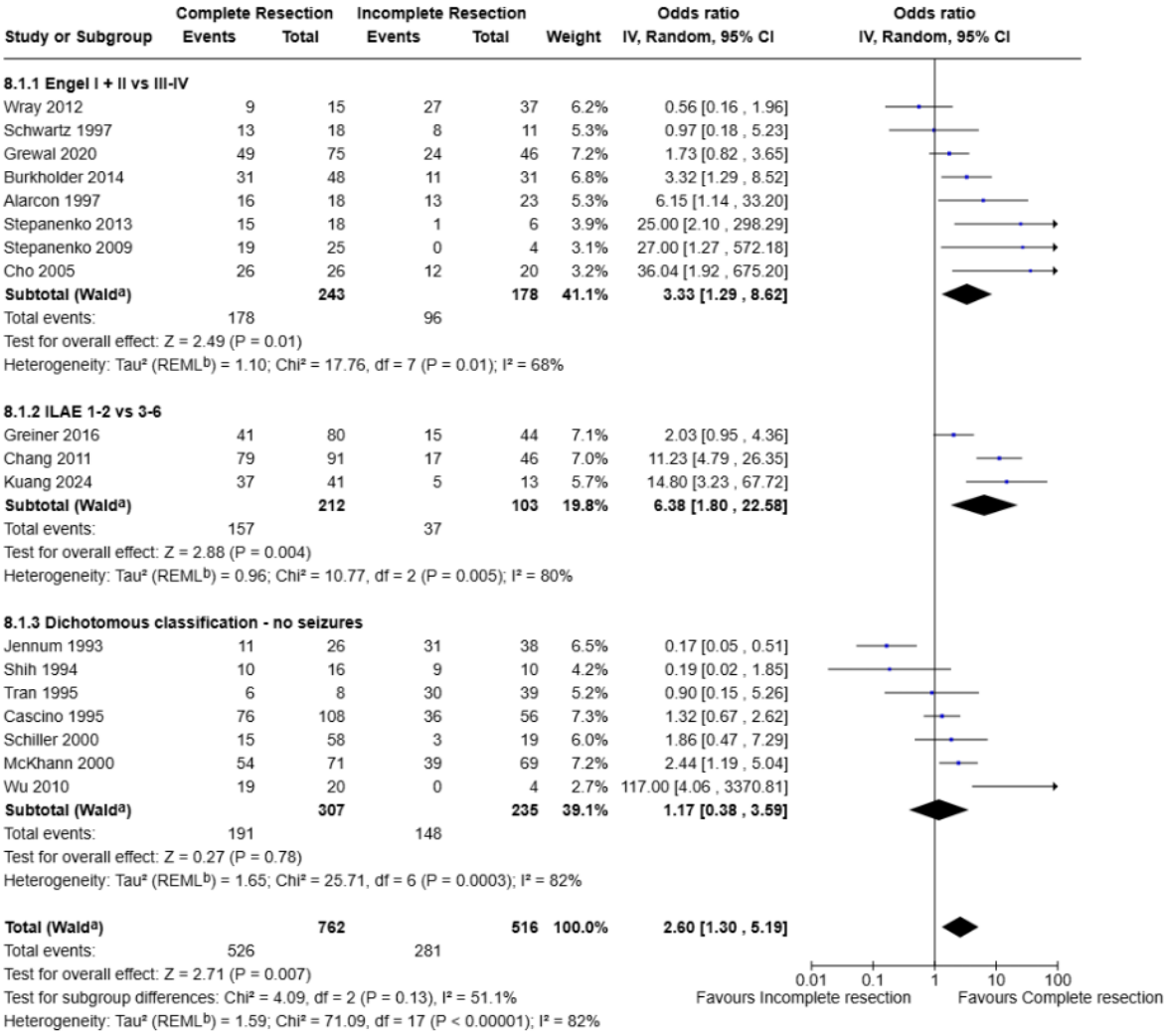


Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

3. Postoperative seizure - Engel I-II vs III-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year



Footnotes

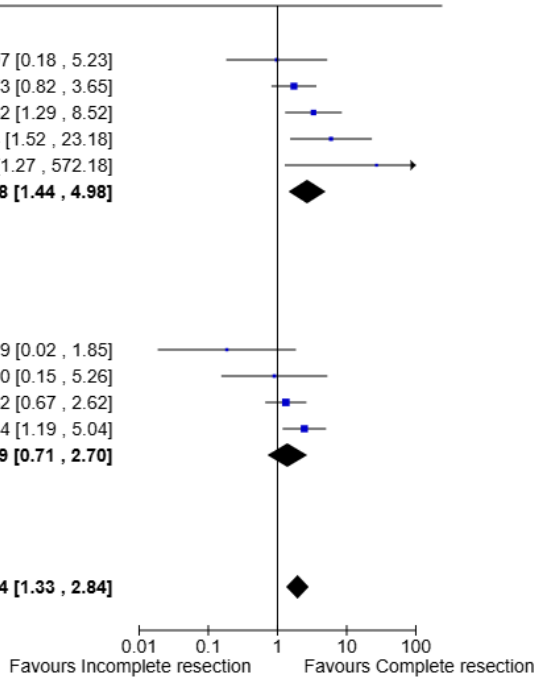
[a]CI calculated by Wald-type method.

[b]Tau² calculated by Restricted Maximum-Likelihood method.

3a. Subgroup – Temporal location

Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year

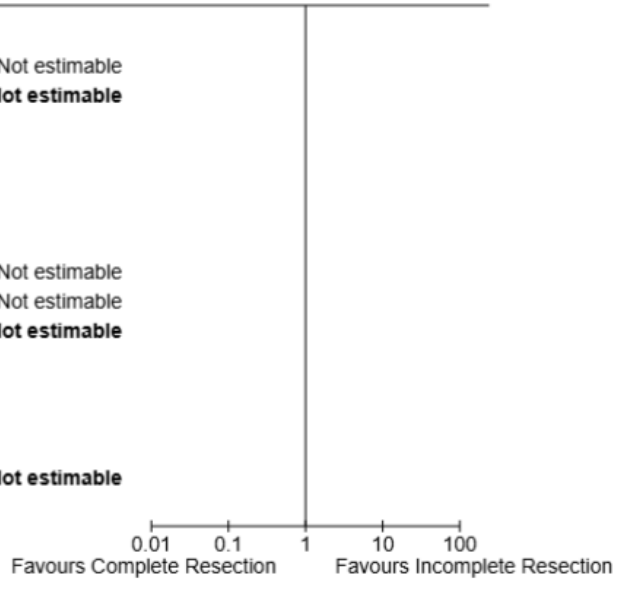
Study or Subgroup	Complete Resection Events	Total	Incomplete Resection Events	Total	Weight	Odds ratio IV, Random, 95% CI
7.3.1 Engel I vs II-IV						
Schwartz 1997	13	18	8	11	4.9%	0.97 [0.18 , 5.23]
Grewal 2020	49	75	24	46	20.4%	1.73 [0.82 , 3.65]
Burkholder 2014	31	48	11	31	13.9%	3.32 [1.29 , 8.52]
Alarcon 1997	13	18	7	23	7.2%	5.94 [1.52 , 23.18]
Stepanenko 2009	19	25	0	4	1.5%	27.00 [1.27 , 572.18]
Subtotal (Wald[a])		**184**		**115**	**47.9%**	**2.68 [1.44 , 4.98]**
Total events:	125		50			
Test for overall effect: Z = 3.11 (P = 0.002)						
Heterogeneity: Tau² (REML[b]) = 0.12; Chi² = 6.37, df = 4 (P = 0.17); I² = 23%						
7.3.2 Dichotomous classification - no seizures						
Shih 1994	10	16	9	10	2.7%	0.19 [0.02 , 1.85]
Tran 1995	6	8	30	39	4.4%	0.90 [0.15 , 5.26]
Cascino 1995	76	108	36	56	23.4%	1.32 [0.67 , 2.62]
McKhann 2000	54	71	39	69	21.5%	2.44 [1.19 , 5.04]
Subtotal (Wald[a])		**203**		**174**	**52.1%**	**1.39 [0.71 , 2.70]**
Total events:	146		114			
Test for overall effect: Z = 0.96 (P = 0.34)						
Heterogeneity: Tau² (REML[b]) = 0.16; Chi² = 5.37, df = 3 (P = 0.15); I² = 35%						
Total (Wald[a])		**387**		**289**	**100.0%**	**1.94 [1.33 , 2.84]**
Total events:	271		164			
Test for overall effect: Z = 3.43 (P = 0.0006)						
Test for subgroup differences: Chi² = 2.01, df = 1 (P = 0.16), I² = 50.2%						
Heterogeneity: Tau² (REML[b]) = 0.04; Chi² = 13.77, df = 8 (P = 0.09); I² = 11%						



Footnotes
[a]CI calculated by Wald-type method.
[b]Tau² calculated by Restricted Maximum-Likelihood method.

4. Mortality

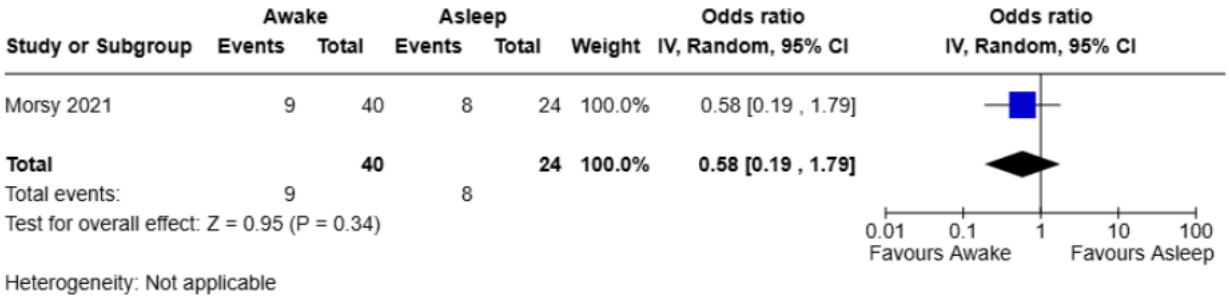
Study or Subgroup	Awake Events	Total	Asleep Events	Total	Weight	Odds ratio IV, Random, 95% CI
9.1.1 Surgical mortality						
Cho 2005	0	26	0	20		Not estimable
Subtotal		**26**		**20**		**Not estimable**
Total events:	0		0			
Test for overall effect: Not applicable						
Heterogeneity: Not applicable						
9.1.2 Postoperative mortality						
Shih 1994	0	16	0	10		Not estimable
Stepanenko 2013	0	18	0	6		Not estimable
Subtotal		**34**		**16**		**Not estimable**
Total events:	0		0			
Test for overall effect: Not applicable						
Heterogeneity: Not applicable						
Total		**60**		**36**		**Not estimable**
Total events:	0		0			
Test for overall effect: Not applicable						
Test for subgroup differences: Not applicable						
Heterogeneity: Not applicable						



PICO 3: Do psychological and psychiatric outcomes differ among patients undergoing awake vs. asleep intraoperative ECoG recording?

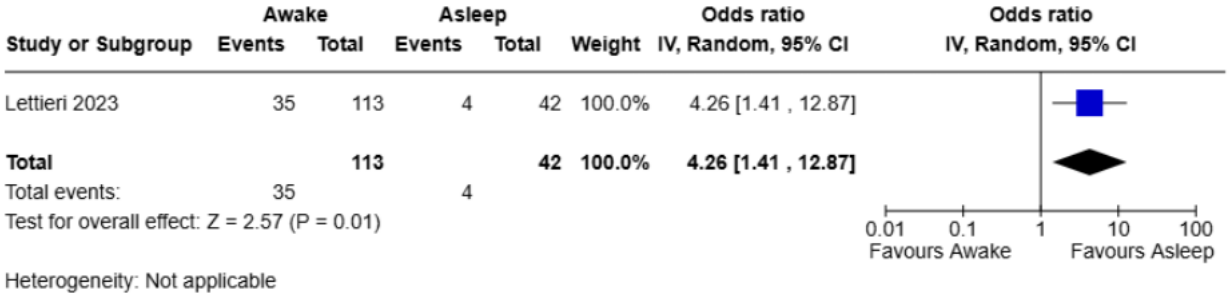
POSTOPERATIVE SEIZURE

1. Postoperative seizure occurred; classified as Yes/No - (Follow up: >2weeks - ≤12 months) (unadjusted)

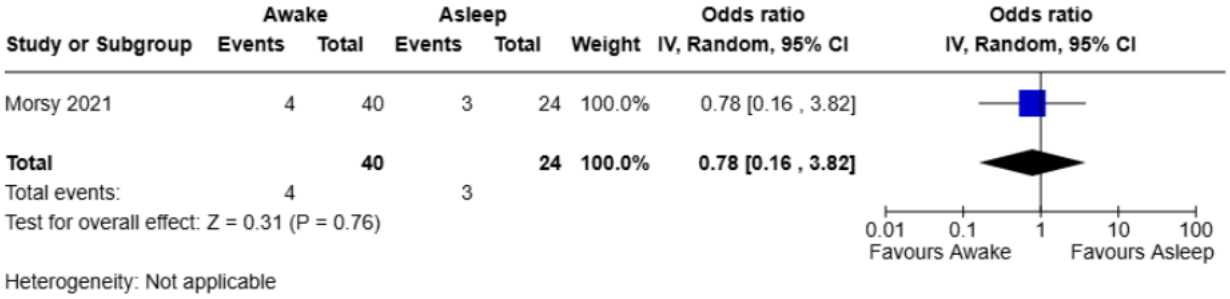


INTROPERATIVE SEIZURE

2. Intraoperative seizure; any kind (adjusted)



3. Intraoperative seizure; stimulation induced (unadjusted)

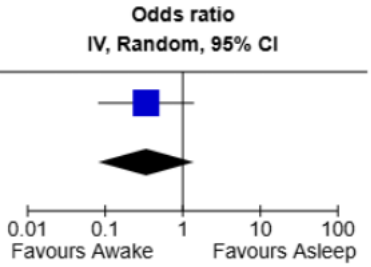


4. Intraoperative seizure; stimulation induced (clinical only) (unadjusted)

Study or Subgroup	Awake Events	Awake Total	Asleep Events	Asleep Total	Weight	Odds ratio IV, Random, 95% CI
Conte 2006	8	25	7	12	100.0%	0.34 [0.08 , 1.39]
Total		**25**		**12**	**100.0%**	**0.34 [0.08 , 1.39]**
Total events:	8		7			

Test for overall effect: Z = 1.50 (P = 0.13)

Heterogeneity: Not applicable

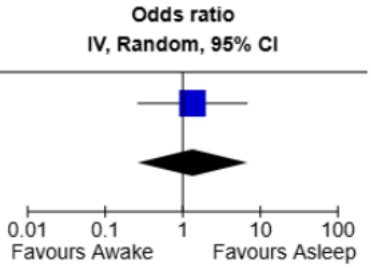


5. Intraoperative seizure; stimulation induced (electrical only) (unadjusted)

Study or Subgroup	Awake Events	Awake Total	Asleep Events	Asleep Total	Weight	Odds ratio IV, Random, 95% CI
Conte 2006	20	25	9	12	100.0%	1.33 [0.26 , 6.83]
Total		**25**		**12**	**100.0%**	**1.33 [0.26 , 6.83]**
Total events:	20		9			

Test for overall effect: Z = 0.35 (P = 0.73)

Heterogeneity: Not applicable

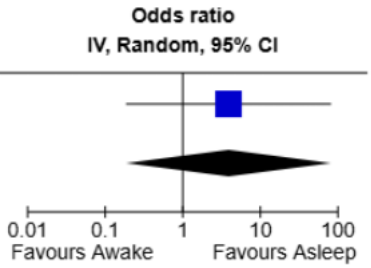


6. Intraoperative seizure; clinical seizures during closing of craniotomy (unadjusted)

Study or Subgroup	Awake Events	Awake Total	Asleep Events	Asleep Total	Weight	Odds ratio IV, Random, 95% CI
Conte 2006	3	25	0	12	100.0%	3.89 [0.19 , 81.52]
Total		**25**		**12**	**100.0%**	**3.89 [0.19 , 81.52]**
Total events:	3		0			

Test for overall effect: Z = 0.87 (P = 0.38)

Heterogeneity: Not applicable



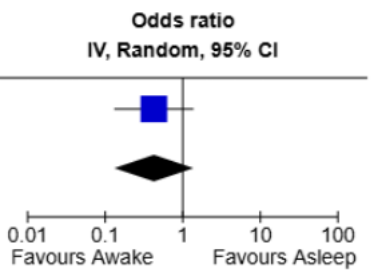
ADVERSE EVENTS

7. Medical or medication-related adverse events (AE) (unadjusted)

Study or Subgroup	Awake Events	Awake Total	Asleep Events	Asleep Total	Weight	Odds ratio IV, Random, 95% CI
Morsy 2021	7	40	8	24	100.0%	0.42 [0.13 , 1.38]
Total		**40**		**24**	**100.0%**	**0.42 [0.13 , 1.38]**
Total events:	7		8			

Test for overall effect: Z = 1.43 (P = 0.15)

Heterogeneity: Not applicable



Appendix 4: GRADE Evidence profiles

PICO 1: Should intraoperative electrocorticography (ECoG), compared to no intraoperative ECoG, be used for patients undergoing resective brain surgery?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ECoG	No ECoG	Relative (95% CI)	Absolute (95% CI)		
1. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up <=2 weeks												
1[1]	Non-randomised studies	very serious[a]	not serious	not serious	very serious[b]	none	26/49 (53.1%)	48/70 (68.6%)	**OR 0.52** (0.24 to 1.10)	**15** fewer per 100 (from 34 fewer to 2 more)	⨁⨁◯◯ Low[a,b]	CRITICAL
2. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >2 weeks to <=6 months)												
2[2,3,c]	non-randomised studies	very serious[a]	very serious[d]	not serious	serious[e]	none	22/22 (100.0%)	12/13 (92.3%)	**OR 1.07** (0.38 to 3.04)	**0 fewer per 100** (from 10 fewer to 5 more)	⨁◯◯◯ Very low[a,d,e]	CRITICAL
3. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >6 months to <=1 year)												
6[2,3,4,5,6,7,f]	non-randomised studies	very serious[a]	very serious[g]	not serious	serious[e]	none	187/222 (84.2%)	102/149 (68.5%)	**OR 1.34** (0.59 to 3.06)	**6 more per 100** (from 12 fewer to 18 more)	⨁◯◯◯ Very low[a,e,g]	CRITICAL
4. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted RCT) (follow-up >1 year)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ECoG	No ECoG	Relative (95% CI)	Absolute (95% CI)		
1[8]	randomised trials	serious[h]	not serious	not serious	extremely serious[i]	none	23/23 (100.0%)	18/19 (94.7%)	**OR 3.81** (0.15 to 99.08)	**4 more per 100** (from 22 fewer to 5 more)	⨁◯◯◯ Very low[h,j]	CRITICAL
5. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >1 year)												
30[2,3,4,6,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,j]	non-randomised studies	very serious[k]	very serious[d]	not serious	not serious	none	707/932 (75.9%)	594/817 (72.7%)	**OR 1.43** (1.03 to 1.99)	**7 more per 100** (from 1 more to 11 more)	⨁◯◯◯ Very low[d,k]	CRITICAL
6. Mortality (follow-up <2 weeks post-op)												
2[5,6]	non-randomised studies	very serious[c]	not serious	not serious	very serious[d]	none	1/131 (0.8%)	1/84 (1.2%)	**OR 0.17** (0.01 to 2.91)	**1 fewer per 100** (from 1 fewer to 2 more)	⨁◯◯◯ Very low[c,d]	CRITICAL
7. Mortality (follow-up ≥2 years post-op)												
7[11,13,14,21,24,34,37]	non-randomised studies	very serious[c]	not serious	not serious	serious[b]	none	0/178 (0.0%)	0/136 (0.0%)	not estimable		⨁◯◯◯ Very low[b,c]	CRITICAL
8. Serious Adverse Event (any) (unadjusted RCT) (follow-up ≥2 years post-op)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ECoG	No ECoG	Relative (95% CI)	Absolute (95% CI)		
1[1]	randomised trials	serious[a]	not serious	not serious	extremely serious[t]	none	1/23 (4.3%)	0/19 (0.0%)	**OR 2.60** (0.10 to 67.56)	**0 fewer per 100** (from 0 fewer to 0 fewer)	⨁◯◯◯ Very low[a,t]	CRITICAL
9. Serious Adverse Event (any) (unadjusted) (follow-up ≥2 years post-op)												
2[4,10,13,14,24,30]	non-randomised studies	very serious[c]	very serious[r]	not serious	serious[b]	none	6/162 (3.7%)	7/127 (5.5%)	**OR 0.96** (0.21 to 4.46)	**0 fewer per 100** (from 4 fewer to 15 more)	⨁◯◯◯ Very low[b,c,r]	CRITICAL
10. Intra-operative seizure (unadjusted) (follow-up mean 3.7 years post-op)												
1[38]	non-randomised studies	very serious[c]	not serious	not serious	serious[b]	none	40/243 (16.5%)	20/234 (8.5%)	**OR 2.11** (1.19 to 3.73)	**8 more per 100** (from 1 more to 17 more)	⨁◯◯◯ Very low[b,c]	IMPORTANT

CI: confidence interval; OR: odds ratio

Explanations

a. Downgraded 2 levels for ROB (ROBINS-I): Non-randomized study(ies) with no statistical adjustment for confounders; unblinded outcome assessment.

b. Downgraded 2 levels for imprecision: CI indicates that the true effect could be a harm or benefit; small sample size

c. The number of events and patients in each group was reported by one of the two studies. Robertson only reported OR with a total N of 116. Data was available for the same cohort in Robertson at 30 days and 6 months: extracted for Evidence Table at 6 months. Analyzed using generic inverse variance.

d. Downgraded 2 levels for inconsistency: point estimates are not similar and indicate both harm and benefit. As a result, did not downgrade for imprecision due to confidence interval crossing line of no effect.

e. Downgraded 1 level for imprecision: small sample size

f. The number of events and patients in each group was reported by one of the two studies. Robertson only reported OR with a total N of 116. Analyzed using generic inverse variance.

g. Downgraded 2 levels for inconsistency: moderate heterogeneity; point estimates are not similar and indicate both harm and benefit. As a result, did not downgrade for imprecision due to wide CI.

h. Downgraded 1 level for ROB: unblinded outcome assessment: this outcome requires clinical judgement and could be affected by knowledge of intervention. Outcomes were not pre-specified in the trial registry.

i. Downgraded 3 levels for imprecision: CI indicates that the true effect could be a significant benefit or a significant harm; small sample size; extremely large CI

j. The number of events and patients in each group was reported by one of the two studies. Robertson only reported OR with a total N of 50. Data was available for the same cohort in Robertson at 2 years and 5 years: extracted for Evidence Table at 5 years. Analyzed using generic inverse variance.

k. Downgraded 2 levels for ROB (ROBINS-I): Non-randomized studies that mention statistical adjustment for confounders but do not provide details: Non-randomized studies with no statistical adjustment for confounders; unblinded outcome assessment.

l. Downgraded 2 levels for imprecision: CI indicates that the true effect could be a benefit or a harm; small sample size

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PICO 2: Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Complete resection	Incomplete resection	Relative (95% CI)	Absolute (95% CI)		
1. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >6 months to ≤1 year												
3[1,2,3]	non-randomised studies	very serious[a]	very serious[b]	not serious	very serious[c]	none	81/100 (81.0%)	59/105 (56.2%)	**OR 1.23** (0.04 to 42.12)	**5 more per 100** (from 51 fewer to 42 more)	⨁◯◯◯ Very low[a,b,c]	CRITICAL
2. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year												
19 [1,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21]	non-randomised studies	very serious[a]	very serious[b]	not serious	very serious[c]	none	521/762 (68.4%)	267/516 (51.7%)	**OR 2.82** (1.36 to 5.84)	**23 more per 100** (from 8 more to 34 more)	⨁◯◯◯ Very low[a,b,c]	CRITICAL
3. Postoperative seizure - Engel I-II vs III-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Complete resection	Incomplete resection	Relative (95% CI)	Absolute (95% CI)		
18 [1,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20]	non-randomised studies	very serious[a]	very serious[b]	not serious	very serious[c]	none	526/762 (69.0%)	281/516 (54.5%)	**OR 2.60** (1.30 to 5.19)	**21 more per 100** (from 6 more to 32 more)	⨁◯◯◯ Very low[a,b,c]	CRITICAL

4. Mortality

3[7,9,16]	non-randomised studies	very serious[a]	not serious	not serious	serious[d]	none	No surgical mortality was reported in either arm for 46 adult and pediatric patients with medically intractable epilepsy detected by MRI in a single study. No postoperative mortality was reported in either arm for 50 patients in two studies: patients with symptomatic epilepsy due to isolated forms of focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD and adults with intractable complex partial seizure (CPS) of the temporal lobe region who received anterior temporal lobectomy.				⨁◯◯◯ Very low[a,d]	CRITICAL

5. Neurological complications (unadjusted) - follow up 30 months

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Complete resection	Incomplete resection	Relative (95% CI)	Absolute (95% CI)		
1[7]	non-randomised studies	very serious[a]	not serious	not serious	serious[d]	none	No neurological complications were reported in either arm for 24 patients with symptomatic epilepsy due to isolated forms of focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD in a single study.				⨁◯◯◯ Very low[a, d]	CRITICAL

CI: confidence interval; OR: odds ratio

Explanations

a. Downgraded 2 level for ROB: non-randomized studies that did not control for confounders; unblinded outcome assessment.

b. Downgraded 2 levels for inconsistency: point estimates indicate both a significant benefit and a significant harm; extremely high heterogeneity.

c. Downgraded 2 levels for imprecision: small sample size; very wide confidence interval (downgraded for wide CI in addition to inconsistency based on severity).

d. Downgraded 1 level for imprecision: small sample size

e. Downgraded 1 level for inconsistency: point estimates indicate both a significant benefit and a significant harm.

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PICO 3: Do psychological and psychiatric outcomes differ among patients undergoing awake vs. asleep intraoperative ECoG recording?

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Awake ECOG	Asleep ECOG	Relative (95% CI)	Absolute (95% CI)		
1. Postoperative seizure occurred; classified as Yes/No - (Follow up: >2weeks - ≤12 months) (unadjusted)												
1[1]	non-randomised studies	very serious [a]	not serious	not serious	very serious [b]	none	9/40 (22.5%)	8/24 (33.3%)	**OR 0.58** (0.19 to 1.79)	**11 fewer per 100** (from 25 fewer to 14 more)	⨁◯◯◯ Very low[a, b]	CRITICAL
2. Intraoperative seizure; any kind (adjusted)												
1[2]	non-randomised studies	very serious [c]	not serious	not serious	very serious [d]	none	35/113 (31.0%)	4/42 (9.5%)	**OR 4.69** (1.50 to 14.66)	**24 more per 100** (from 4 more to 51 more)	⨁◯◯◯ Very low[c, d]	CRITICAL
3. Intraoperative seizure; stimulation induced (unadjusted)												
1[1]	non-randomised studies	very serious [a]	not serious	not serious	very serious [b]	none	4/40 (10.0%)	3/24 (12.5%)	**OR 0.78** (0.16 to 3.82)	**2 fewer per 100** (from 10 fewer to 23 more)	⨁◯◯◯ Very low[a, b]	CRITICAL
4. Intraoperative seizure; stimulation induced (clinical only) (unadjusted)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Awake ECOG	Asleep ECOG	Relative (95% CI)	Absolute (95% CI)		
1[3]	non-randomised studies	very serious[a]	not serious	not serious	serious[b]	none	8/25 (32.0%)	7/12 (58.3%)	**OR 0.34** (0.08 to 1.39)	**26 fewer per 100** (from 48 fewer to 8 more)	⨁◯◯◯ Very low[a, b]	CRITICAL
5. Intraoperative seizure; stimulation induced (electrical only) (unadjusted)												
1[3]	non-randomised studies	very serious[a]	not serious	not serious	serious[e]	none	20/25 (80.0%)	9/12 (75.0%)	**OR 1.33** (0.26 to 6.83)	**5 more per 100** (from 31 fewer to 20 more)	⨁◯◯◯ Very low[a, e]	CRITICAL
6. Intraoperative seizure; clinical seizures during closing of craniotomy (unadjusted)												
1[3]	non-randomised studies	very serious[a]	not serious	not serious	serious[e]	none	3/25 (12.0%)	0/12 (0%)	**OR 3.89** (0.19 to 81.52)	**0 fewer per 100** (from 0 fewer to 0 fewer)	⨁◯◯◯ Very low[a, e]	CRITICAL
7. Medical or medication-related adverse events (AE) (unadjusted)												
1[1]	non-randomised studies	very serious[a]	not serious	not serious	very serious[b]	none	7/40 (17.5%)	8/24 (33.3%)	**OR 0.42** (0.13 to 1.38)	**16 fewer per 100** (from 27 fewer to 7 more)	⨁◯◯◯ Very low[a, b]	CRITICAL

CI: confidence interval; **OR:** odds ratio

Explanations

a. Downgraded 2 levels for risk of bias: non-randomized study that did not adjust for confounding.

b. Downgraded 2 levels for imprecision: small sample size; point estimate that conveys both a benefit and harm.

c. Downgraded 2 levels for risk of bias: non-randomized study that adjusted for confounding but did not provide details.

d. Downgraded 2 levels for imprecision: small sample size; wide confidence interval

e. Downgraded 3 levels for imprecision: small sample size; point estimate that conveys both a benefit and harm; wide confidence interval.

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Appendix 5: Evidence To Decision Framework

PICO 1: Should intraoperative electrocorticography (ECoG), compared to no intraoperative ECoG, be used for patients undergoing resective brain surgery?

Assessment

Problem Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Intraoperative electrocorticography (ECoG) is the recording of electrophysiological activity from electrodes placed directly on the exposed surface of brain, during surgery for epilepsy and tumour resection. Intraoperative ECoG is helpful in defining the seizure onset and spread within the cortical surface and delineation of the interface between epileptogenic zones and functional cortex substance of the brain. Intraoperative ECoG is an invasive procedure, it is performed during surgery mostly commonly during awake craniotomy but at times during general anaesthesia. Intraoperative ECoG gained initial wide acceptance, but its role has diminished over time. The decline in use of ECoG could in part be related to the development of chronic implanted intracranial subdural and depth electrodes, which allowed detection of not only interictal but also ictal findings. An informal poll of topic experts suggested that only half of United States epilepsy centres routinely perform ECoG during the majority of the epilepsy surgeries in their institution. There are centres where such practice is rare overall. This shift in clinical care leads to a question of whether ECoG has the ability to improve postoperative seizure outcomes and is a necessary tool during the resection.	7 in-meeting votes: probably yes (1), yes (6) 7 on-line votes: probably yes (1), yes (6) Overall: probably yes (2), yes (2) Final vote: Yes 14/15 cast votes
Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ● Small ○ Moderate ○ Large ○ Varies	**Post-operative seizure** Thirty-seven studies (1 RCT (2), 36 non-randomized studies (see references at the end of SOF table) reported post-operative seizure outcomes in patients receiving either ECoG or no ECoG. The outcomes were measured using Engel Classification (1	**Notes in meeting 15/10/2025** 15/10/2025 - for "Seizure free"

<table>
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<td>○ Don't know</td>
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RCT, 28 non-randomized studies), ILAE Classification (4 non-randomized studies) or no formal classification method (3 non-randomized studies).

Based on clinical use of the different classification systems, the panel agreed to combine the values for Engel I vs II-IV, Engel IA vs all, ILAE 1-2 vs 3-6 and "Seizure free" at 4 different time points (≤ 2 weeks, >2 weeks to ≤ 6 months, >6 months to ≤1 year, and >1 year). The panel also agreed on a 5% clinically important difference (i.e. the threshold for meaningful patient benefit) for the outcome of post-operative seizures.
For post-operative seizures occurring>2 weeks to ≤6 months, 2 non-randomized studies (n=151) with very low certainty of evidence, reported there was no clinically important difference.

For post-operative seizures occurring>6 months to ≤1 year, 6 non-randomized studies (n=487) with very low certainty of evidence reported a probably clinically important difference with 6 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold.

For post-operative seizures occurring>1 year, 1 RCT (n=42) with a low certainty of evidence reported there was no clinically important difference.

For post-operative seizures occurring>1 year, 30 non-randomized studies (n=1479) with a very low certainty of evidence reported a probably clinically important difference, with 7 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold. The overall effect was statistically significant with unadjusted OR 1.43 (95% CI 1.03, 1.99).
<table>
<tr><th rowspan="2">Outcomes</th><th colspan="2">Anticipated absolute effects* (95% CI)</th><th rowspan="2">Relative effect (95% CI)</th><th rowspan="2">№ of participants (studies)</th><th rowspan="2">Certainty of the evidence (GRADE)</th><th rowspan="2">Comments</th></tr>
<tr><th>Risk with no intraoperative ECoG</th><th>Risk with intraoperative electrocorticography (ECoG)</th></tr>
<tr><td rowspan="2">2. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted</td><td colspan="2">Study population</td><td rowspan="2">OR 1.07
(0.38 to 3.04)</td><td rowspan="2">35
(2 non-randomised studies)[1,2,a]</td><td rowspan="2">⨁◯◯◯
Very low[b,c,d]</td><td rowspan="2"></td></tr>
<tr><td>92 per 100</td><td>93 per 100
(82 to 97)</td></tr>
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5 in-meeting votes: trivial (1), small (4)
6 on-line votes: small (3), large (2), don't know (1)

Overall: trivial (1), small (7), large (2), don't know (1)
Final vote: Small
11/15 cast votes

Agreed 5% MID threshold

Subgroup analysis depending on tumour/ non-tumour categories?? Chairs to assign studies to population categories (probably tumour group, and congenital vs acquired)

Shawna (summary from conversation): "Categories to use: Lesional, non-lesional, genetic, or other Lesional included tumor" - MS confirms subgroup analysis is pre-planned for the above groups.
</td>
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) (follow-up >2 weeks to ≤6 months)							
3. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >6 months to ≤1 year)	Study population		**OR 1.34** (0.59 to 3.06)	371 (6 non-randomised studies)[1,2,3,4,5,6,e]	⨁◯◯◯ Very low[b,d,f]	
	68 per 100	**74 per 100** (56 to 87)				
4. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted RCT) (follow-up >1 year)	Study population		**OR 3.81** (0.15 to 99.08)	42 (1 RCT)[7]	⨁◯◯◯ Very low[g,h]	
	95 per 100	**99 per 100** (73 to 100)				
5. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up >1 year)	Study population		**OR 1.43** (1.03 to 1.99)	1749 (30 non-randomised studies)[1,10,11,12,13,14,15,16,17,18,19,2,20,21,22,23,24,25,26,27,28,29,3,30,31,32,33,5,8,9,i]	⨁◯◯◯ Very low[c,j]	
	73 per 100	**79 per 100** (73 to 84)				

	Comments: Outcome #2: Evidence from 2 NRS (n=35) suggests there may be little to no difference in the risk of seizures between 2 weeks and 6 months follow-up (92.8% vs 92.3%, OR 1.07, 95% CI 0.38, 3.04); however the certainty of the evidence is very low. The wide confidence interval indicates that there can be a substantial reduction to no clinically relevant difference in the proportion of people who are seizure-free (10.3% fewer to 5% more). Outcome #3: Evidence from 6 NRS (n=371) suggests that ECoG may result in more people being "seizure-free" at 6-12 months follow-up (74.4% vs 68.8%, OR 1.34, 95% CI 0.59, 3.06); however, the certainty of the evidence is very low. The wide confidence interval indicates there can be a substantial reduction to a substantial increase in the proportion of people who are seizure-free (ranging from 12.3% fewer to 18.5% more). Outcome #4: Evidence from one RCT (n=42) suggests that ECoG may result in little to no difference in the risk of post-operative seizures at >1 year follow-up (98.8% vs 94.7%, OR 3.81, 95% CI 0.15, 99.08), but the certainty of the evidence is very low. The wide confidence interval indicates that there can be a substantial reduction to no clinically relevant difference in the proportion of people who are seizure-free (ranging from 21.8% fewer to 5.2% more). Outcome #5: Evidence from 30 NRS (n=1479) suggests that ECoG may result in a reduction in the risk of post-operative seizures at >1 year follow-up (79.2% vs 72.7% seizure free, OR 1.43, 95% CI 1.03, 1.99); however, the certainty of the evidence is very low. The wide confidence interval indicates that there can be a substantial increase to no clinically relevant difference in the proportion of people who are seizure-free (ranging from 0.6% to 11.4% more). Secondary to the combined values above, the panel also expressed interest in **Engel I-II vs III-IV and ILAE 1-3 vs 4-6** based on patient preferences. For post-operative seizures occurring **>2 weeks to ≤6 months**, 1 non-randomized study (n=116) with very low certainty of evidence reported a ***no clinically important difference.*** For post-operative seizures occurring **>6 months to ≤1 year**, 2 non-randomized studies (n=224) with very low certainty of evidence reported a ***probably clinically important difference*** with 11 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold. For post-operative seizures occurring **>1 year**, 14 non-randomized studies (n=643) with very low certainty of evidence reported a ***probably clinically important difference*** with 8 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold.	

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no intraoperative ECoG	Risk with intraoperative electrocorticography (ECoG)				
6. Post-operative seizure - Engel I-II vs III-IV; ILAE 1-3 vs 4-6 (unadjusted) (follow-up >2 weeks to ≤6 months)	Study population		**OR 1.60** (0.31 to 8.31)	(1 non-randomised study)[1,a]	⨁◯◯◯ Very low[b,c]	Evidence from 1 NRS (n=116) suggests that ECoG may result in a reduction in the risk of post-operative seizures at 6 months (unadjusted OR 1.60, 95% CI 0.31 , 8.31) (no data on absolute effects available); however the certainty of the evidence is very low.
	0 per 100	**0 per 100** (0 to 0)				
7. Post-operative seizure - Engel I-II vs III-IV; ILAE 1-3 vs 4-6 (unadjusted) (follow-up >6 months to ≤1 year)	Study population		**OR 2.35** (0.27 to 20.86)	108 (2 non-randomised studies)[1,2,d]	⨁◯◯◯ Very low[b,e,f]	Evidence from 2 NRS (n=108) suggests that ECoG may result in more people being "seizure free" or have rare seizures at 6 months to 1 year follow-up. (89.2% vs 77.8%; OR 2.35, 95% CI 0.27, 20.86); however, the certainty of the evidence is very low. The wide confidence interval indicates there can be a substantial reduction to a substantial increase in the proportion of people who are seizure-free/rare seizures (ranging from 29.2% fewer to 20.9% more).
	78 per 100	**89 per 100** (49 to 99)				
8. Post-operative seizure - Engel I-II vs III-IV; ILAE 1-3 vs 4-6 (unadjusted) (follow-up >1 year)	Study population		**OR 1.81** (0.85 to 3.86)	593 (14 non-randomised studies)[1,10,11,12,13,14,15,3,4,5,6,7,8,9,g]	⨁◯◯◯ Very low[b,e,f]	Evidence from 14 NRS (n=593) suggests that ECoG may result in more people being "seizure free" or have rare seizures after 1 year follow-up (88.9% vs 81.6%; OR 1.81, 95% CI 0.85, 3.86); however, the certainty of the
	82 per 100	**89 per 100** (79 to 94)				

						evidence is very low. The wide confidence interval indicates there can be a substantial reduction to a substantial increase in the proportion of people who are seizure-free/rare seizures (ranging from 2.6% fewer to 12.9% more).	

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large ○ Moderate ○ Small ● Trivial ○ Varies ○ Don't know	**Post-operative seizure** For post-operative seizures occurring **≤2 weeks**, 1 non-randomized study (n=119) with very low certainty of evidence reported a ***probably clinically important difference*** with 15 fewer patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold.	**Notes in meeting 15/10/2025** Post-operative seizure up to 2 weeks follow-up The study includes a non-typical population (people with glioblastoma), which may explain the "negative" results. Mortality - there is no indication of increased mortality, but it is important to note studies are underpowered to detect differences in mortality, but it is not an expected outcome in clinical practice.

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no intraoperative ECoG	Risk with intraoperative electrocorticography (ECoG)				
1. Post-operative seizure - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "No Seizures" (Unadjusted) (follow-up ≤2 weeks	Study population		**OR 0.52** (0.24 to 1.10)	119 (1 non-randomised study)[1]	⨁◯◯◯ Very low[a,b]	Evidence from one NRS (n=119) suggests that there may be a higher risk of seizures at up to 2 weeks follow-up (53.2% vs 68.6%, OR 0.52, 95% CI 0.24, 1.10); however the certainty of the evidence is very low. The wide confidence interval indicates that there can be a substantial reduction to no clinically relevant difference in the proportion of people who are seizure-free (ranging from 34.2% fewer to 2% more).
	69 per 100	**53 per 100** (34 to 71)				

Mortality Nine non-randomized studies (n= 529, very low certainty of evidence) reported on mortality as an outcome in patients receiving ECoG or no ECoG. Only one study reported any deaths, with one death in each arm, both from brain edema (3). Both patients died in the first week post-surgery. No other deaths were reported in any time frame.

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with no intraoperative ECoG	Risk difference with intraoperative electrocorticography (ECoG)
9. Mortality (follow-up <2 weeks post-op)	215 (2 non-randomised studies)[1,2]	⨁◯◯◯ Very low[a,b]	**OR 0.17** (0.01 to 2.91)	Study population	
				1 per 100	**1 fewer per 100** (1 fewer to 2 more)
10. Mortality (follow-up ≥2 years post-op)	314 (7 non-randomised studies)[3,4,5,6,7,8,9]	⨁◯◯◯ Very low[a,c]	not estimable	Study population	
				0 per 100	**0 fewer per 100** (0 fewer to 0 fewer)

Serious Adverse Events

Seven studies (1 RCT (n=42, low certainty evidence); 6 non-randomized studies (n=289, very low certainty of evidence)) reported on serious adverse events (SAE) as an outcome in patients receiving ECoG or no ECoG. There was ***no clinically important difference*** between the two groups. All the SAE were reported 16 months or more post-operative. A total of 15 SAE were reported: stroke (1), hemorrhage (2), cerebral edema (2), extradural hematoma (1), transient hemiparesis (2), and permanent complications of mild aphasia (2), diplopia (1), nystagmus (1), superior quadrantanopsia (1), mild hemiparesis (1), and mild memory impairment (1).

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with no intraoperative ECoG	Risk difference with intraoperative electrocorticography (ECoG)
29. Serious Adverse Event (any) (unadjusted RCT) (follow-up ≥2 years post-op)	42 (1 RCT)[1]	⨁◯◯◯ Very low[a,b]	**OR 2.60** (0.10 to 67.56)	Study population	
				0 per 100	**0 fewer per 100** (0 fewer to 0 fewer)
				Study population	

SAEs - similar to mortality, there is no indication of higher risk of SAEs.

Intra-operative seizures - there may be an increase in intraoperative seizures. Evidence derives from a single NRS. The procedure itself (craniotomy) may increase the risk of seizures.

- Van: It may not be a "bad" seizure, in that it is a focal seizure.
- Stephan explains they conducted a similar study with similar results.
- Marissa noted baseline seizure frequency pre-op is important when looking at seizure outcomes.

One panel member commented that they voted don't know because they believe the Nossek study should be thrown out based on the non-generalizability of the population.

30. Serious Adverse Event (any) (unadjusted) (follow-up ≥2 years post-op)	289 (6 non-randomised studies)[2,3,4,5,6,7]	⨁◯◯◯ Very low[c,d,e]	**OR 0.96** (0.21 to 4.46)	6 per 100	**0 fewer per 100** (4 fewer to 15 more)

Intra-operative Seizure

One non-randomized study (4) of 477 patients (very low certainty of evidence) reported on intra-operative seizures as an outcome. The unadjusted comparison reported intra-operative seizures were more frequent in patients receiving ECoG compared to those who did not (unadjusted OR 2.11 (95% CI 1.19, 3.73; p=0.01)), which is ***probably clinically important*** as the confidence interval passes the CID threshold of 5%.

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no intraoperative ECoG	Risk with intraoperative electrocorticography (ECoG)				
13. Intra-operative seizure (unadjusted) (follow-up mean 3.7 years post-op)	Study population		**OR 2.11** (1.19 to 3.73)	477 (1 non-randomised study)[1]	⨁◯◯◯ Very low[a,b]	Evidence from 1 NRS (n=477) suggests that ECoG may result in more people experiencing intra-operative seizures (16.5% vs 8.5%; OR 2.11, 95% CI 1.19, 3.73); however, the certainty of the evidence is very low. The wide confidence interval indicates there can be a substantial increase to no clinically relevant difference in the proportion of people who experience intra-operative seizures (ranging from 1.5% more to 17.3% more).
	9 per 100	**16 per 100** (10 to 26)				

Vote
6 In-meeting: trivial (4), small (1), don't know (1)
Dr. Glass objects to inclusion of Nossek trial based on generalizability.
6 On-line: trivial (2), small (2), don't know (2)

Overall: trivial (6), small (3), don't know (3)

Final vote: trivial
12/15 votes cast

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
● Very low ○ Low ○ Moderate ○ High ○ No included studies	All of the non-randomized studies (n=36) had a ***very low certainty*** of evidence, mainly due to risk of bias (no adjustment for confounding factors), inconsistency for the pooled outcomes and indirectness (small sample sizes, wide conference intervals and estimates that indicated both harm and benefit). The single RCT study had a ***low certainty*** of evidence as it scored better in the risk of bias domain due to randomization. Similar concerns with indirectness small sample size, wide conference intervals that indicated both harm and benefit) were noted for the RCT.	Vote 6 In-meeting: very low (4), low (2) 6 On-line: very low (2), low (2), moderate (2) Overall: very low (6), low (2), moderate (2) **Total: Very low** 12/15 votes

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ● No	No evidence on patient values relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified.	In terms of value of the outcomes, there are two different populations included and values will vary based on the type of tumor/lesion. Based on their clinical experience, the panelists noted patients with glioblastoma and high grade tumors may more strongly value survival and minimize neurological deficit while patient with medically intractable epilepsy may more strongly value

important uncertainty or variability		quality of life and being seizure free. The high amount of heterogeneity and variability between the studies would influence outcome values, however there may be no uncertainty or variability in within the subgroups, but between the subgroups, there may be. Vote 7 In-meeting: important (1), probably no (2), no important (4) 6 On-line: important (1), possibly (3), no important (2) Overall: Important (2), Possibly (3), Probably no (2), no important (6) **Final: no important uncertainty or variability** 13/15 votes

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	**Desirable effects:** For **post-operative seizures** occurring**>6 months to ≤1 year**, 6 non-randomized studies (n=487) with very low certainty of evidence reported a ***probably clinically important difference*** with 6 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold. For **post-operative seizures** occurring **>1 year**, 30 non-randomized studies (n=1479) with a very low certainty of evidence reported a ***probably clinically important difference,*** with 7 more patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold. The overall effect was statistically significant with unadjusted OR 1.43 (95% CI 1.03, 1.99). At the other time frame of **>2 weeks to ≤6months** there was ***no clinically important difference*** reported (very low certainty of evidence). The single RCT at **>1 year** (n=42) with a low certainty of evidence reported there was ***no clinically important difference.*** **Undesirable effects:** For **post-operative seizures** occurring **≤2 weeks**, 1 non-randomized study (n=119) with very low certainty of evidence reported a ***probably clinically important difference*** with 15 fewer patients out of 100 being seizure-free in the ECoG group, however the confidence interval crosses the CID threshold. The panel noted this study is in a non-typical population of glioblastoma patients. For the outcomes of **mortality and SAEs** there is no indication of increased risk of events, but it is important to note studies are underpowered to detect differences in these outcomes. For the outcome of **intra-operative seizure** the unadjusted comparison (n=477) reported intra-operative seizures were more frequent in patients receiving ECoG compared to those who did not (unadjusted OR 2.11 (95% CI 1.19, 3.73; p=0.01)), which is a ***probably clinically important difference*** as the confidence interval passes the CID threshold of 5% (very low certainty of evidence).	-low threshold to use ECoG based on the opinion that the undesirable effects are very low and the desirable effects are relatively important, where the chances to become seizure free are slightly better. -benefits outweigh the risks, many of the risk are temporary. Vote: 7 In-meeting: does not favor (1), probably favors ECoG (5), favors ECoG (1) 6 On-line: probably favors ECoG (2), favors ECoG (4) Overall: does not favor (1), probably favors ECoG (7), favors ECoG (5) **Final: probably favors ECOG** 13/15 votes

Resources required		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	No evidence on costs relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified. ~200-500 USD for physician 250-500 ECoG services per year for Medicare (this is adult coverage only) Consider -costs for training -costs for medical equipment -costs for additional OR or surgeon time	The fee schedule (CPT code 95829) lists ECoG as ~200-500 USD. One panellist referred to the cost of ECoG as "background noise" as it is so inexpensive compared to the rest of the surgery. Hospitals already own the equipment and any additional training is part of a clinical fellowship. A registered EEG tech would need some additional training, but at minimal cost. The electrodes are a non-reusable item, the cost of which is rolled into the hospital fee. Vote: 8 In-meeting: moderate costs (2), negligible (6) 6 On-line: moderate costs (2), negligible (2), moderate savings (2) Overall: moderate costs (4), negligible (8), moderate savings (2) Final: negligible costs and savings

		13/15 voted

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ○ Low ● Moderate ○ High ○ No included studies	No evidence on costs relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified.	The panel acknowledged costs could vary state by state. The costs are believed to be negligible to moderate, but there is a lot of variation in our certainty of those costs. No comparative cost evidence is available. Vote: 8 In-meeting: very low (1), low (1), moderate (5), high (1) 6 On-line: very low (2), moderate (3), no included studies (1) Overall: very low (3), low (1), moderate (8), high (1), no included studies (1)

		Final: Moderate 14/15 voted

Cost effectiveness

Does the cost-effectiveness of the intervention favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention	A meta-analysis (5) of individual patient data (IPD) examining the benefit of ECoG during resective epilepsy surgery in achieving seizure freedom for various pathologies reported that on average 8.8 patients must be treated with ECoG to achieve one beneficial outcome (one additional patient with seizure freedom) (number needed to treat (NNT) ECoG = 8.8; NNT ECoG in FCD = 4.7). They also reported that seizure freedom following ECoG varied across centers.	Based on the evidence from (5), the panel felt that a NNT of 9 was acceptable. In comparison, Dr. Selioutski provided NNT data on epilepsy drug treatment (oxcarbazepine) which would be much more expensive and less effective (50% reduction in seizures, not seizure free) (NNT 3-7). Vote: 8 In-meeting: Does not favor (2), probably favors intervention (3), favors intervention (3)

○ Favors the intervention ○ Varies ○ No included studies		6 On-line: Does not favor (1), probably favors intervention (2), varies (1), no included studies (2) Overall: Does not favor (3), probably favors intervention (5), favors intervention (3), varies (1), no included studies (2) **Final: probably favors intervention** 14/15 voted

Equity

What would be the impact on health equity?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Reduced ○ Probably reduced ● Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know	No evidence on equity relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified. Consider populations that are traditionally underrepresented in medical research due to systemic barriers such as: -racialized groups -refugees and immigrants -Native or Indigenous Peoples -2SLGBTQ+ -women -pregnant women -frail elderly -people experiencing homelessness -justice involved people/people experiencing incarceration	Panel member noted that ECoG is not the rate-limiting step in regards to health equity. Vote: 7 In-meeting: Varies (3), probably no impact (4) 6 On-line: probably no impact (2), no included studies (4) Overall: probably no impact (6), no included studies (4), varies (3) **Final: probably no impact** 13/15 votes

Acceptability Is the intervention acceptable to key interest-holders?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● Don't know	No evidence on acceptability relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified. Consider the debate around the usefulness of ECoG and the evidence presented above of studies that show a clear benefit and others that show harm.	Based on their professional experience, the panel noted patients had not expressed any concerns about the use of ECoG and that it's use was a surgeon preference. Based on clinical expertise the panel members noted they would vote yes/probably yes based on experience, however in the absence of published evidence many voted don't know. Vote: 7 In-meeting: Probably yes (3), yes (1), varies (1), don't know (2) 6 On-line: probably yes (1), yes (2), don't know (3) Overall: probably yes (4), yes (3), varies (1), don't know (5) **Final: Don't know** 13/15 voted

Feasibility Is the intervention feasible to implement?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	No evidence on feasibility relating to intraoperative ECoG vs no intraoperative ECoG in persons undergoing resective brain surgery was identified. Consider - technical feasibility - economic viability / resource requirements - operational considerations	Panel members agreed that ECoG is a commonplace, straightforward procedure, but it can be a technical challenge due to all the artifacts (hostile environment electrically) in the operating room. Advanced planning is mandatory, with trained and experienced staff (surgeon/neurophysiologist, technician). Vote: 4 In-meeting: probably yes (1), yes (2), varies (1) 6 In-meeting: probably yes (2), yes (4) Overall: probably yes (3), yes (6), varies (1) **Final: Yes** 10/15 Voted

Summary of judgements

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	**Small**	Moderate	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	Small	**Trivial**		Varies	Don't know
CERTAINTY OF EVIDENCE	**Very low**	Low	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	Probably no important uncertainty or variability	**No important uncertainty or variability**			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	**Negligible costs and savings**	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	Low	**Moderate**	High			No included studies
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	No included studies

	JUDGEMENT						
EQUITY	Reduced	Probably reduced	**Probably no impact**	Probably increased	Increased	Varies	Don't know
ACCEPTABILITY	No	Probably no	Probably yes	Yes		Varies	**Don't know**
FEASIBILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know

Type of recommendation

Strong recommendation against the intervention ○	Conditional recommendation against the intervention ○	Conditional recommendation for either the intervention or the comparison ○	**Conditional recommendation for the intervention** ●	Strong recommendation for the intervention ○

Conclusions

Recommendation

We suggest using intraoperative electrocorticography (ECoG) vs. no intraoperative ECoG in patients undergoing resective brain surgery (conditional recommendation, very low certainty of evidence).

Remarks: (*exceptions, key considerations)*
Needs to be based on individual patient situation/needs and information already available.
Based on training available.
Prolonging surgery can lead to increased risk of infection, however there is a lack of evidence.
It's possible a pre-operative intracranial evaluation might reduce need for ECoG, however there is no evidence.

Votes: 5 – conditional recommendation for either; 5 – conditional recommendation for the intervention. The panel agreed a recommendation for either was not appropriate for a single intervention vs no intervention. Final decision was conditional recommendation for the intervention.

Justification

There is probably a clinically important difference for post-operative seizures.
ECoG appears to be a relatively safe and low-cost procedure.

The potential benefits of ECoG outweigh the risk, particularly regarding temporary adverse events.

Subgroup considerations

Postoperative Seizure - LOW-GRADE TUMOR - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year) : OR 1.17 [0.72 , 1.89], no clinical difference or statistical significance, 10 non-randomized studies (495 patients), very low certainty of evidence.
Postoperative Seizure - High-grade tumor - 2 studies (n= 123)
Postoperative Seizure - Non-tumor - 4 studies (221)

Postoperative Seizure -LESION - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year): OR: 1.45 (1.03, 2.04), no clinical difference, 28 non-randomized studies (166 patients), very low certainty of evidence.

Postoperative Seizure -NON-GENETIC - Engel I vs II-IV; Engel IA vs all; ILAE 1-2 vs 3-6; "Seizure free" (unadjusted) (follow up: >1 year) OR: 1.36 [0.95 , 1.93], no clinical difference or statistical significance, 24 non-randomized studies (1554 patients), very low certainty of evidence.

After an off-line discussion on classification of 'genetic', the non-genetic subgroup was re-analyzed, this time removing all previous 'mixed' studies, cavernomas and FCD. The revised OR was not clinically or statistically significant between ECoG and No ECoG groups.
Non-genetic (version 2) OR: 1.40 [0.85 , 2.30]
Non-genetic OR: 1.36 [0.95 , 1.93]
Overall analysis OR: 1.43 [1.03 , 1.99]

Implementation considerations

Quality assurance and improvement:
Documentation of the discussion on potential benefits and harms between provider and patient that considers:

- Individual patient's values
- Pre/post mental health assessment
- Better documentation as to if/why patient was offered/declined ECoG - as there is currently a lack of evidence.
- Clear documentation as to why/why not ECoG was offered by the physician team to each unique patient. Note changes in the tools and pratice standards over time may lead to a better understanding of epilepsy.

Monitoring and evaluation

- ECoG findings need to be consistently included in longitudinal follow up of outcomes

Research priorities

- ECoG findings need to be consistently included in longitudinal follow up of outcomes
- Further RCT studies are needed to improve the certainty of the evidence

Future research topics:

- Should phase 2 monitoring (intracranial) replace ECOG (long term recording instead of short-term ECoG recordings)?
- Determine whether ECoG can be used to improve precision of the responsive neuro stimulation (RNS placement)

PICO 2: Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?

Assessment

Problem Is the problem a priority?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	Intraoperative electrocorticography (ECoG) is the recording of electrophysiological activity from electrodes placed directly on the exposed surface of brain, during surgery for epilepsy and tumour resection. Intraoperative ECoG is helpful in defining the seizure onset and spread within the cortical surface and delineation of the interface between epileptogenic zones and functional cortex substance of the brain. Intraoperative ECoG is an invasive procedure, it is performed during surgery mostly commonly during awake craniotomy but at times during general anaesthesia. Intraoperative ECoG gained initial wide acceptance, but its role has diminished over time. The decline in use of ECoG could in part be related to the development of chronic implanted intracranial subdural and depth electrodes, which allowed detection of not only interictal but also ictal findings. An informal poll of topic experts suggested that only half of United States epilepsy centres routinely perform ECoG during the majority of the epilepsy surgeries in their institution. There are centres where such practice is rare overall. This shift in clinical care leads to a question of whether ECoG has the ability to improve postoperative seizure outcomes and is a necessary tool during the resection. **Do the outcomes of complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, differ?**	VOTE 5 In-meeting: yes (5) 6 On-line: no (1), probably yes (2), yes (3) Overall: no (1), probably yes (2), yes (8) **Final: Yes** 11/15 Voted
Desirable Effects How substantial are the desirable anticipated effects?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know	**Post-operative seizure** Twenty-one non-randomized studies (see references at the end of SOF table) reported post-operative seizure outcomes in patients receiving either complete or incomplete resection, as defined by abnormal ECoG findings. The outcomes were measured using Engel Classification (9 non-randomized studies), ILAE Classification (4 non-randomized studies) or no formal classification method (7 non-randomized studies). Based on clinical use of the different classification systems, the panel agreed to combine the values for Engel I vs II-IV, Engel IA vs all, ILAE 1-2 vs 3-6 and "Seizure free" at 4 different time points (≤ 2 weeks, >2 weeks to ≤ 6 months, >6 months to ≤1 year, and >1 year). The panel also agreed on a 5%	These findings at >1 year agree with a previous systematic review on epilepsy surgery which reported complete resection of tissue that displayed interictal epileptiform discharges in oECoG predicted favorable seizure outcome better

clinically important difference (i.e. the threshold for meaningful patient benefit) for the outcome of post-operative seizures. For post-operative seizures occurring **>6 months to ≤1 year**, 3 non-randomized studies (n=205) with ***very low certainty of evidence*** reported with ***no clinically important difference.*** For post-operative seizures occurring **>1 year**, 18 non-randomized studies (n=1295) with a ***very low certainty of evidence*** reported a ***clinically important difference***, with 23 more patients out of 100 being seizure-free in the complete resection group. The overall effect was statistically significant with unadjusted OR 2.82 (95% CI 1.36, 5.84).

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with incomplete resection	Risk difference with complete resection
1. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >6 months to ≤1 year	205 (3 non-randomised studies)[1,2,3]	⨁◯◯◯ Very low[a,b,c]	**OR 1.23** (0.04 to 42.12)	Study population	
				56 per 100	**5 more per 100** (51 fewer to 42 more)
2. Postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year	1278 (19 non-randomised studies)[1,10,11,12,13,14,15,16,17,18,19,20,21,4,5,6,7,8,9]	⨁◯◯◯ Very low[a,b,c]	**OR 2.82** (1.36 to 5.84)	Study population	
				52 per 100	**23 more per 100** (8 more to 34 more)

Secondary to the combined values above, the panel also expressed interest in **Engel I-II vs III-IV and ILAE 1-3 vs 4-6** based on patient preferences.

For post-operative seizures occurring **>1 year**, 18 non-randomized studies (n=1295) with a ***very low certainty of evidence*** reported a ***clinically important difference***, with 21 more patients out of 100 being seizure-free in the complete resection group. The overall effect was statistically significant with unadjusted OR 2.60 (95% CI 1.30, 5.19)

compared with incomplete resection (OR 3.04 [1.76–5.25]; $p < 0.01$; low certainty; 23 studies) (1).

VOTE
5 In-meeting: small (1), moderate (2), large (2)
6 On-line: small (2), moderate (2), don't know (2)
Overall: small (3), moderate (4), large (2), don't know (2)
Final: Moderate
11/15 Voted

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with incomplete resection	Risk difference with complete resection
3. Postoperative seizure - Engel I-II vs III-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1 year	1278 (18 non-randomised studies)[1,10,11,12,13,14,15,16,17,18,2,3,4,5,6,7,8,9]	⨁◯◯◯ Very low[a,b,c]	**OR 2.60** (1.30 to 5.19)	Study population	
				54 per 100	**21 more per 100** (6 more to 32 more)

Undesirable Effects

How substantial are the undesirable anticipated effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large ○ Moderate ○ Small ● Trivial ○ Varies ○ Don't know	**Mortality** One non-randomized study (2) (n=46, very low certainty of evidence) reported no deaths in either arm for surgical mortality. Two non-randomized studies ((3, 4) (n=50, very low certainty of evidence) reported no deaths in either arm for postoperative mortality.	VOTE 5 In-meeting: small (2), trivial (3) 6 On-line: small (2), trivial (3) , don't know (1) Overall: small (3), trivial (6), don't know (2) **Final: Trivial** 11/15 Voted

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects* (95% CI)	
				Risk with incomplete resection	Risk difference with complete resection
4. Mortality	0 (3 non-randomised studies)[1,2,3]	⨁◯◯◯ Very low[a,b]	-	No surgical mortality was reported in either arm for 46 adult and pediatric patients with medically intractable epilepsy detected by MRI in a single study. No postoperative mortality was reported in either arm for 50 patients in two studies: patients with symptomatic epilepsy due to isolated forms of focal cortical dysplasia (FCD) or hippocampal sclerosis and low-grade tumours associated with FCD and adults with intractable complex partial seizure (CPS) of the temporal lobe region who received anterior temporal lobectomy.	

	Serious Adverse Events One non-randomized study (4) (n=24, very low certainty of evidence) reported no neurological complications at median 30 months post-operation in either arm.	

Certainty of evidence

What is the overall certainty of the evidence of effects?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	All of the non-randomized studies (n=21) had a ***very low certainty*** of evidence, mainly due to risk of bias (no adjustment or nor information on adjustment for confounding factors), inconsistency for the pooled outcomes and indirectness (small sample sizes, wide conference intervals and estimates that indicated both harm and benefit).	VOTE 5 In-meeting: very low (2), low (3) 6 On-line: very low (3), low (2), moderate (1) Overall: very low (5), low (5), moderate (1) **Final: Low** 11/15 Voted

Values

Is there important uncertainty about or variability in how much people value the main outcomes?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably	No evidence on patient values relating to the outcomes for complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings, in persons undergoing resective brain surgery was identified. Indirect evidence - Research on decision making factors for epilepsy patients choosing surgery over no surgery noted that frequency, severity and length of time with seizures were important deciding factors as well as the need/desire to be seizure-free, the stigma of epilepsy, embarrassment from seizures in public, and frustration with epilepsy (5).	The panel members noted that patients do have the choice of type of surgery and their decision depends on their risk tolerance. In their experience patients often have concerns about memory loss and some choose a less agressive surgery to spare memory loss.

no important uncertainty or variability ● No important uncertainty or variability		VOTE 5 In-meeting: Possibly important uncertainty or variability (1) Probably no important uncertainty or variability (2) No important uncertainty or variability (2) 6 On-line: Important uncertainty or variability (1) Possibly important uncertainty or variability (2) No important uncertainty or variability (3) Overall Important uncertainty or variability (1) Possibly important uncertainty or variability (3) Probably no important uncertainty or variability (2) No important uncertainty or variability (5) **Final: No important uncertainty or variability** 11/15 Voted

Balance of effects

Does the balance between desirable and undesirable effects favor the intervention or the comparison?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Favors the comparison ○ Probably	**Desirable effects:** For **post-operative seizures** occurring**>6 months to ≤1 year**, 3 non-randomized studies (n=205) with ***very low certainty of evidence*** reported with ***no clinically important difference.***	Some panel members expressed concern that there was no evidence on cognitive outcomes which is a very

favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know	For **post-operative seizures** occurring **>1 year**, 18 non-randomized studies (n=1295) with a ***very low certainty of evidence*** reported a ***clinically important difference***, with 23 more patients out of 100 being seizure-free in the complete resection group, however the confidence interval crosses the CID threshold. The overall effect was statistically signficant with unadjusted OR 2.82 (95% CI 1.36, 5.84). **Undesirable effects:** For the outcomes of **mortality and SAEs** there is no indication of increased risk of events, but it is important to note studies are underpowered to detect differences in these outcomes.	important outcome to consider in the balance with desirable effects. Use of ECoG may lead to a more aggressive resection and potentially worse cognitive outcomes. VOTE 5 In-meeting: Probably favors the intervention (3), don't know (2) 6 On-line: does not favor either (2), probably favors the intervention (3), varies (1) Overall: does not favor either (2), probably favors the intervention (6), varies (1), don't know (2) **Final: probably favors the intervention** 11/15 voted

Resources required

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Large costs ○ Moderate costs ● Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know	No evidence on costs relating to complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings in persons undergoing resective brain surgery was identified.	Compared to the overall cost of surgery, the addition of post-resection ECoG is trivial. The Epileptologist will get a fee for interpretation whether it is pre and/or post. Additional costs of the consumable grids and electrodes is also negligible. VOTE 5 In-meeting: Negligible costs and savings (5)

		6 On-line: Moderate costs (2), negligible costs and savings (3), don't know (1) Overall: Moderate costs (2), negligible costs and savings (8), don't know (1) **Final: negligible costs and savings** 11/15 voted

Certainty of evidence of required resources

What is the certainty of the evidence of resource requirements (costs)?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ Very low ● Low ○ Moderate ○ High ○ No included studies	No evidence on costs relating to complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings in persons undergoing resective brain surgery was identified.	VOTE 5 In-meeting: Very low (1), low (1), No included studies (3) 6 On-line: Very low (2), low (3), No included studies (1) Overall: Very low (3), low (4), No included studies (4) **Final: Low** 11/15 voted

Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies	No evidence on cost effectiveness relating to complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings in persons undergoing resective brain surgery was identified.	VOTE 5 In-meeting: Probably favors the intervention (1), No included studies (4) 6 On-line: Does not favor either (1), Probably favors the intervention (2), No included studies (3) Overall: Does not favor either (1), Probably favors the intervention (3), No included studies (7) **Final: No included studies** 11/15 Voted
Equity What would be the impact on health equity?		
JUDGEMENT	**RESEARCH EVIDENCE**	**ADDITIONAL CONSIDERATIONS**
○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably	No evidence on equity concerns relating to complete versus incomplete resection, as defined by abnormal intraoperative ECoG findings in persons undergoing resective brain surgery was identified. Consider populations that are traditionally underrepresented in medical research due to systemic barriers such as: -racialized groups -refugees and immigrants	As with PICO 1, the use of ECoG is not the rate limiting step in regards to equity. VOTE

increased ○ Increased ○ Varies ● Don't know	-Native or Indigenous Peoples -2SLGBTQ+ -women -pregnant women -frail elderly -people experiencing homelessness -justice involved people/people experiencing incarceration	5 In-meeting: Probably no impact (3), Don't know (2) 6 On-line: Probably no impact (2), Increased (1), Don't know (3) Overall: Probably no impact (5), Increased (1), Don't know (5) **Final: Don't know** 11/15 Voted

Acceptability

Is the intervention acceptable to key interest-holders?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know	The National Association of Epilepsy Centres released guidelines for specialized epilepsy centers in 2024 informed by systematic evidence review and a panel of experts (6). One of the 52 recommendations was that all centers that perform resective surgeries should have the ability to perform intraoperative electrocorticography to identify epileptogenic tissue and that electrocorticography should be interpreted by epileptologists or neurophysiologists with sufficient volume of cases to maintain expertise.	Panel members considered the recommendations from the NAEC valuable as patients look for the highest level of care centers (levels 3 and 4) and this is where these recommendations are directed. VOTE 5 In-meeting: Probably yes (3), Yes (2) 6 On-line: Probably yes (2), Yes (4) Overall: Probably yes (5), Yes (6) **Final: Yes** 11/15 Voted

Feasibility

Is the intervention feasible to implement?

JUDGEMENT	RESEARCH EVIDENCE	ADDITIONAL CONSIDERATIONS
○ No ○ Probably no ○ Probably yes	The National Association of Epilepsy Centres released guidelines for specialized epilepsy centers in 2024 informed by systematic evidence review and a panel of experts (6). One of the 52 recommendations was that all centers that perform resective surgeries should have the ability to perform intraoperative electrocorticography to identify epileptogenic tissue and that electrocorticography should be interpreted by epileptologists or neurophysiologists with sufficient volume of cases to maintain expertise.	VOTE 5 In-meeting: Probably yes (1), Yes (4) 6 On-line: Probably yes (2), Yes (4) Overall: Probably yes (3), Yes (8) **Final: Yes**

● Yes ○ Varies ○ Don't know	A draft ACNS guideline for Minimum Technical Requirements for Performing Intraoperative ECoG states "ECoG remains an indispensable tool during surgical resections." (7) (in press: Journal of Clinical Neurophysiology)	11/15 Voted

Summary of judgements

	JUDGEMENT						
PROBLEM	No	Probably no	Probably yes	**Yes**		Varies	Don't know
DESIRABLE EFFECTS	Trivial	Small	**Moderate**	Large		Varies	Don't know
UNDESIRABLE EFFECTS	Large	Moderate	Small	**Trivial**		Varies	Don't know
CERTAINTY OF EVIDENCE	Very low	**Low**	Moderate	High			No included studies
VALUES	Important uncertainty or variability	Possibly important uncertainty or variability	Probably no important uncertainty or variability	**No important uncertainty or variability**			
BALANCE OF EFFECTS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	**Probably favors the intervention**	Favors the intervention	Varies	Don't know
RESOURCES REQUIRED	Large costs	Moderate costs	**Negligible costs and savings**	Moderate savings	Large savings	Varies	Don't know
CERTAINTY OF EVIDENCE OF REQUIRED RESOURCES	Very low	**Low**	Moderate	High			No included studies

	JUDGEMENT						
COST EFFECTIVENESS	Favors the comparison	Probably favors the comparison	Does not favor either the intervention or the comparison	Probably favors the intervention	Favors the intervention	Varies	**No included studies**
EQUITY	Reduced	Probably reduced	Probably no impact	Probably increased	Increased	Varies	**Don't know**
ACCEPTABILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know
FEASIBILITY	No	Probably no	Probably yes	**Yes**		Varies	Don't know

Type of recommendation

Strong recommendation against the intervention	Conditional recommendation against the intervention	Conditional recommendation for either the intervention or the comparison	Conditional recommendation for the intervention	Strong recommendation for the intervention
○	○	○	○	○

Conclusions

Recommendation

We suggest using intraoperative ECoG findings to determine complete versus incomplete resection in patients undergoing resective brain surgery (conditional recommendation, very low certainty of evidence).

Remarks: (*exceptions, key considerations)*
Within safety boundaries - does not contradict or compromise safety (ie. language area, eloquent cortex area).

Justification

There is evidence supporting post-operative seizure reduction.
The panel noted a lack of evidence on neurology outcomes / serious adverse events.
The panel noted there is potential confounding in that the default is incomplete resection due to potential damage to the eloquent cortex.

Subgroup considerations

Temporal location - 9 studies reporting postoperative seizure - Engel I vs II-IV, ILAE 1-2 vs 3-6, "Seizure free" - follow up >1.
Similar results to the overall analysis.
For **post-operative seizures** occurring **>1 year** in the **temporal location subgroup**, 9 non-randomized studies (n=676) with a ***very low certainty of evidence*** reported a ***clinically important difference***, with 15 more patients out of 100 being seizure-free in the complete resection group. The overall effect was statistically significant with unadjusted OR 1.94 (95% CI 1.33, 2.84).

Implementation considerations

Quality assurance and improvement:
Documentation of the discussion on potential benefits and harms between provider and patient that considers:

- Individual patient's values
- Pre/post mental health assessment
- Better documentation as to if/why patient was offered/declined ECoG - as there is currently a lack of evidence.
- Clear documentation as to why/why not ECoG was offered by the physician team to each unique patient. Note changes in the tools and pratice standards over time may lead to a better understanding of epilepsy.

Monitoring and evaluation

- Only length of follow up can determine success of the operation.

Research priorities

- Determine whether ECoG can be used to improve precision of the responsive neuro stimulation (RNS placement)
- Further RCT studies are needed to improve the certainty of the evidence
- Longer post-op follow up for ECoG studies.

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