Original article

Ukrainian Neurosurgical Journal. 2026;32(1):60-68
doi: 10.25305/unj.339497

Global research trends on seizure detection in critical care after decompressive craniectomy: A bibliometric analysis

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Received: 17 September 2025
Accepted: 03 November 2025

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Background: Postoperative seizures are a recognized complication following decompressive craniectomy (DC); the global research landscape regarding seizure detection in this context remains insufficiently characterized. Bibliometric mapping provides insights into emerging trends and knowledge gaps.

Objective: This study aims to map and evaluate international research output on seizure detection in critically ill patients after decompressive craniectomy.

Methods: Relevant literature was collected from Scopus, PubMed, CrossRef, and Google Scholar using the terms 'decompressive craniectomy AND seizure AND detected' via the Publish or Perish software. Records were exported in RIS format and analysed with VOSviewer to generate keyword co-occurrence networks, cluster maps, and temporal trend visualizations.

Results: A total of 1,605 publications from 2015–2025 were analyzed. Annual research volume increased, particularly since 2018. The co-occurrence network analysis identified four thematic clusters: (1) clinical outcomes and prognosis, (2) surgical techniques and perioperative management, (3) intracranial pressure and monitoring strategies, and (4) seizure detection and critical neurological care. Overlay analysis revealed a gradual thematic shift toward seizure monitoring and electroencephalography EEG-based approaches in recent years, while density visualization confirmed that seizure detection remains an emerging but relatively underdeveloped research area. The most prolific contributor was identified with 126 publications.

Conclusion: Although publications on decompressive craniectomy have grown rapidly, seizure detection remains a relatively small but growing research topic. Increased focus on neurocritical monitoring indicates future opportunities for developing evidence-based protocols and collaborative studies in this field.

Keywords: *decompressive craniectomy; seizure detection; intensive care; bibliometric studies; VOSviewer*

Introduction

Decompressive craniectomy (DC) is a crucial surgical intervention often performed to reduce intracranial pressure in patients with severe brain injury, ischaemic or haemorrhagic stroke who experience refractory cerebral oedema [1-3]. Although DC can save lives by reducing herniation and improving cerebral perfusion, the procedure also places patients at risk of short-term and long-term neurological complications [4-6].

One of the most commonly reported complications is seizures. Seizures in post-DC patients not only worsen neurological dysfunction but are also associated with increased length of intensive care, morbidity, and mortality [7,8]. Therefore, early detection and monitoring of seizures in the critical care unit is an important aspect of postoperative management. The prevalence of post-craniotomy seizures varies, generally ranging from 3% to 30% in various studies, depending on the patient's condition and the type of surgical procedure performed [9, 10].

Clinical challenges surrounding seizure detection in the complex post-DC population: seizures can be clinical or subclinical (non-convulsive), and clinical signs are often masked by sedation, paralysis, or comorbid medical conditions, making clinical-based detection difficult. In this context continuous electroencephalography (cEEG) monitoring, automatic detection algorithms, multimodal monitoring including EEG, intracranial pressure, oximetry), and other non-invasive techniques play a crucial role [11-13].

However, the diversity of protocols, resource availability, variations in seizure definitions, and differences in reported outcomes make the consolidation of clinical knowledge and research challenging.

Although seizures are a common complication after severe brain injury, patients undergoing decompressive craniectomy represent a distinct subgroup due to their altered intracranial physiology and cortical exposure. This subgroup requires specific EEG monitoring approaches and postoperative management strategies, justifying the bibliometric focus on this population.

Over the past two decades, the literature on post-DC seizure detection has grown alongside advances in monitoring technology about portable EEG, machine

learning for EEG pattern detection and increased awareness of the importance of subclinical seizures [14-16]. In the present study, we employed bibliometric approach to describe research trends about seizure in post decompressive craniectomy patient based on numerous case studies such as case series, observational studies, and a number of narrative or systematic reviews.

The reasons for choosing bibliometric studies on this topic are based on several practical and scientific considerations. First, there has been no bibliometric study that systematically maps global trends in research on seizure detection in post-DC with outcomes in intensive care. Second, bibliometric research can also identify methodological trends, whether studies tend to be observational, experimental, or registry-based, thereby providing input for stronger study designs in the future. Third, the identification of international collaboration networks and funding sources can assist policymakers and researchers in designing collaboration strategies or resource allocation.

Given the complexity of clinical phenomena involved and the heterogeneity of the literature, bibliometric studies must be conducted with a clear scope regarding the range of publication years, databases and structured keywords. Analysis methods may involve basic quantitative metrics such as annual publication numbers, citations and H-index. Network analyses — such as author collaboration, citation collaboration, and bibliographic linking — as well as topic modelling or clustering using VOSviewer, CiteSpace, or other bibliometric tools, can be used to identify research trends and topic evolution over time.

Although the number of publications related to decompressive craniectomy has increased rapidly, research on the detection of post-DC seizures is still relatively limited, fragmented, and mostly in the form of observational studies or case reports. In addition, there has been no bibliometric analysis that specifically maps global trends, collaborations, and the direction of research development in this field.

Therefore, this study aims to present a bibliometric mapping of seizure detection in critically ill patients after decompressive craniectomy, thereby providing a foundation for future research development, clinical practice, and health policy.

Materials and methods

Study design

This study employed a bibliometric design to describe publication trends, author collaborations, and research topics related to seizure detection in patients after decompressive craniectomy in the last decades from 2015-2025.

Data sources and search strategy

Bibliographic data were collected from four main sources: Scopus, CrossRef, PubMed, and Google Scholar. Scopus was selected as the primary source due to its broad coverage and high indexing standards. CrossRef was used to obtain publication metadata including titles, authors, publication years, digital object identifiers (DOIs), journal names, and citations. PubMed was selected because it is relevant to the fields of medicine and critical care nursing, and provides peer-reviewed literature in the fields of neuroscience and intensive care. Google Scholar was used to supplement the literature search with a broader range of publications, including articles that may not be indexed in traditional databases. Data collection was carried out using the latest version of Publish or Perish software, which can extract publication metadata from these three sources in RIS format. The search strategy was formulated using a combination of the keywords 'decompressive craniectomy' AND 'seizures' AND 'detected' and complete Boolean operators such as "decompressive craniectomy" OR "craniectomy" AND "seizure" OR "epilepsy" OR "convulsion" AND "detection" OR "monitoring" OR 'EEG' OR "continuous EEG". The search was limited to the year range between 2015 and 2025, publication type must be research articles and reviews, in English and research procedure.

The search was restricted to the period from 2015-2025 in order to capture the post-digital monitoring era, during which continuous EEG and algorithmic seizure detection became more widespread in critical care and neurosurgical settings.

Data analysis

Vosviewer

The analysis was performed using the latest VOSviewer software (version 1.6.19) with the following steps: Descriptive bibliometric analysis: calculating the number of publications per year, journal distribution, citations, and H-index. Network analysis by Co-authorship: to map author and institutional collaborations, Co-citation: to identify the most influential references and Keyword co-occurrence: to find dominant research topics (research hotspots). Bibliometric map visualisation: created with VOSviewer, producing network visualisation, density visualisation, and temporal visualisation (overlay visualisation) maps to see developments.

PRISMA flowchart

Brief methodology used by researchers during processing. RIS parsing: each RIS file is separated per entry, then common tags are extracted. Duplicate removal prioritises DOI as the key and when DOI is unavailable, normalised titles are used. Records are filtered to include only publications between 2015 ≤ year ≤ 2025. Prioritise relevance of titles, abstracts and keywords containing the terms decompressive craniectomy, craniectomy and craniotomy as well as terms related to seizures. Only documents with tags, journal indicators or articles included are retrieved. Each included record was manually screened to confirm that the population involved decompressive craniectomy or hemicraniectomy. Studies limited to closed-skull traumatic brain injury (TBI) without surgical decompression were excluded. Heuristic clinical trial method by searching for the phrases clinical trial, randomised, RCT, controlled trial, or tags containing Clinical Trial.

Results

Although 1,605 records were analysed for bibliometric mapping, only 13 met strict inclusion for detailed descriptive synthesis focusing specifically on

This article contains some figures that are displayed in color online but in black and white in the print edition.

EEG-based seizure detection following DC. This explains the apparent discrepancy between PRISMA and total bibliometric data (***Fig. 1***).

Base on mapping of research topic clusters, keywords related to decompressive craniectomy and seizure detection are distributed across several main clusters. The purple cluster focuses on seizures, detection, and neurocritical care representing research on post-operative seizure complications following craniectomy and both clinical and instrumental detection efforts. The green cluster is related to the terms management, review, craniotomy, acute subdural haematoma, and medical treatment emphasizing aspects of critical care management following DC. The blue cluster is dominated by the keywords including cranioplasty, intracranial hypertension, monitoring, and risk factors, reflecting research on postoperative intracranial pressure management and associated risks. The red cluster contains terms such as admission, Glasgow Coma Scale (GCS), discharge, mean age, outcome, and significant difference indicating a focus on patient characteristics, neurological assessment scores, and clinical outcomes. Notably, the keywords 'seizure' and 'detection' are located at the edge of the network, suggesting that these topics are still niche research area with limited connectivity compared to other major topics such as intracranial hypertension and postoperative management (***Fig. 2***).

The changes in research focus based on year of publication shows the distribution of research publication. Yellow indicates more recent research (2021–2022), while blue-violet denotes earlier research. Initial research predominantly focused on intracranial hypertension, cranioplasty, and management. In contrast, current trends (2021–2022) show an increased focus on admission characteristics, outcome measures (GOS, the Rankin scale), and seizure detection in critical care units. This indicates a shift in research from purely surgical aspects to neurological monitoring and patient outcomes, including seizure complications (***Fig. 3***).

Base on the research topic intensity and saturation level, the yellow areas indicate the most frequently occurring keywords and the focus of the research. The most prominent words are 'management', 'intracranial hypertension', and 'cranioplasty'. Meanwhile, the terms 'seizure', "detection", and 'neurocritical care', although appearing, are still in areas with lower intensity, indicating that literature related to seizure detection after decompressive craniectomy is still relatively limited compared to other topics (***Fig. 4***).

Description

Based on ***Figs. 2, 3 and 4***, research on seizure detection in patients after DC has begun to appear in the literature, but it is still marginalized compared to major themes such as intracranial hypertension management and post-operative outcomes. Recent trends show a

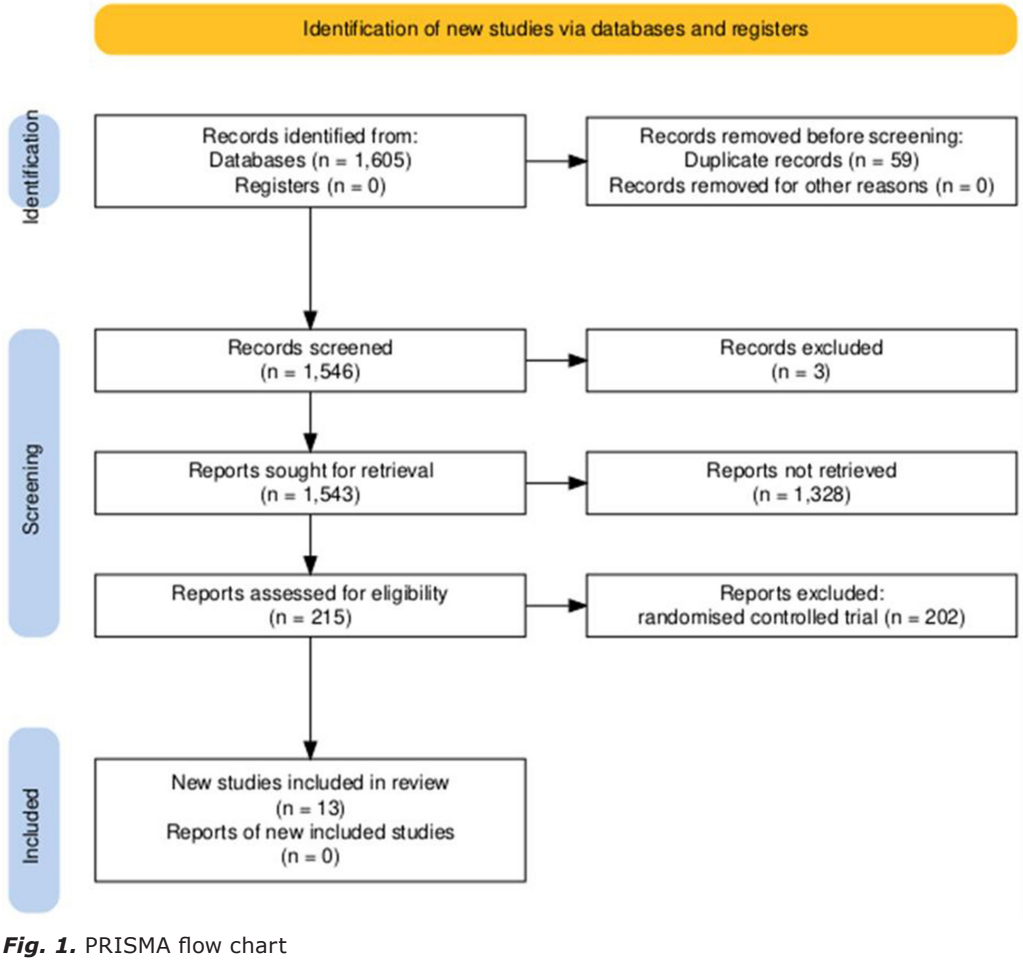

Fig. 1. PRISMA flow chart

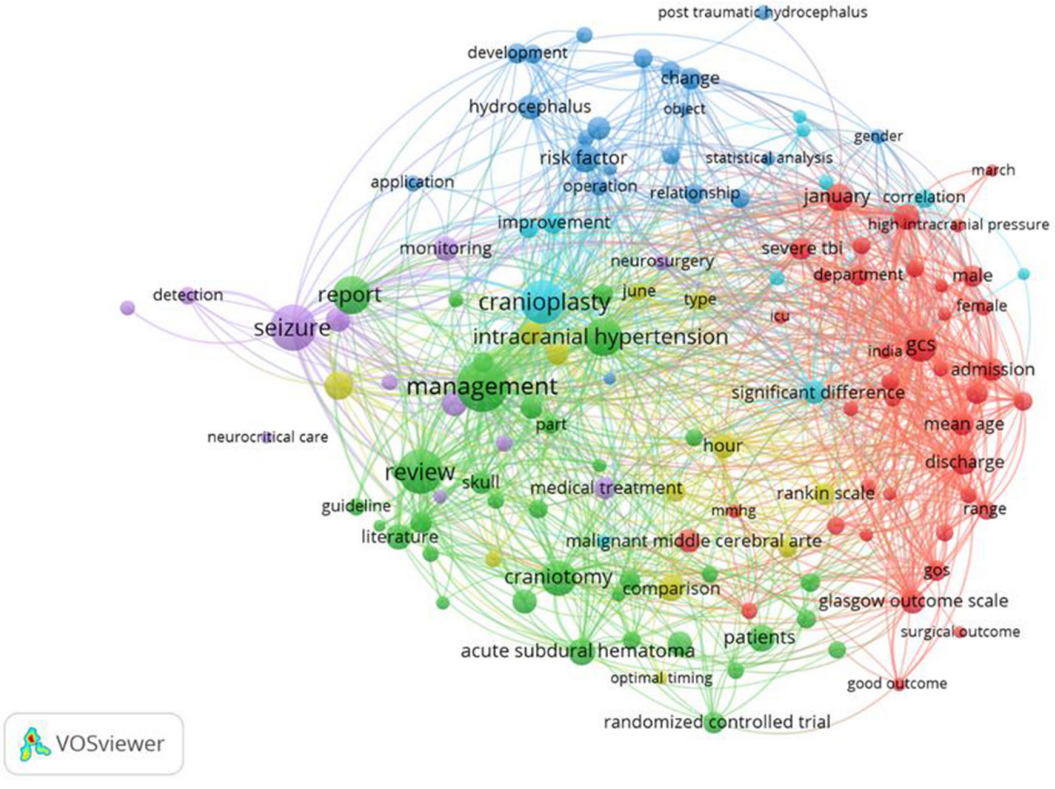

Fig. 2. Mapping of research topic clusters

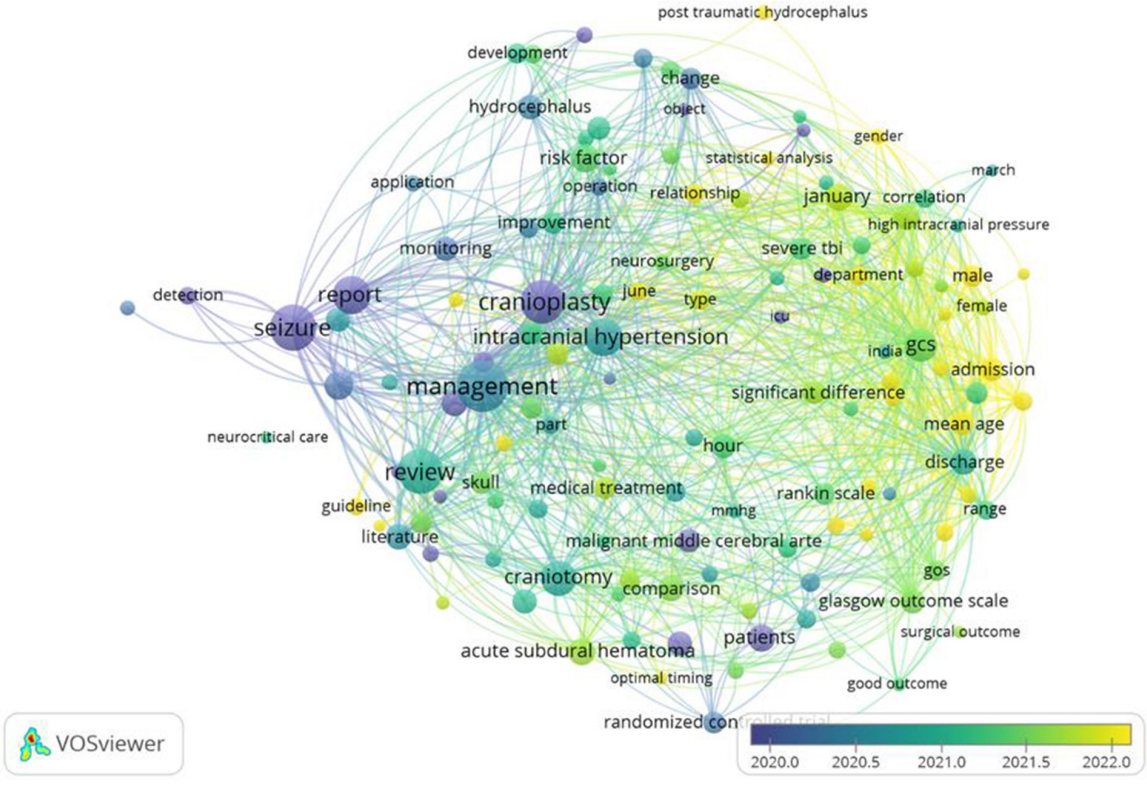

Fig. 3. Changes in research focus based on year of publication

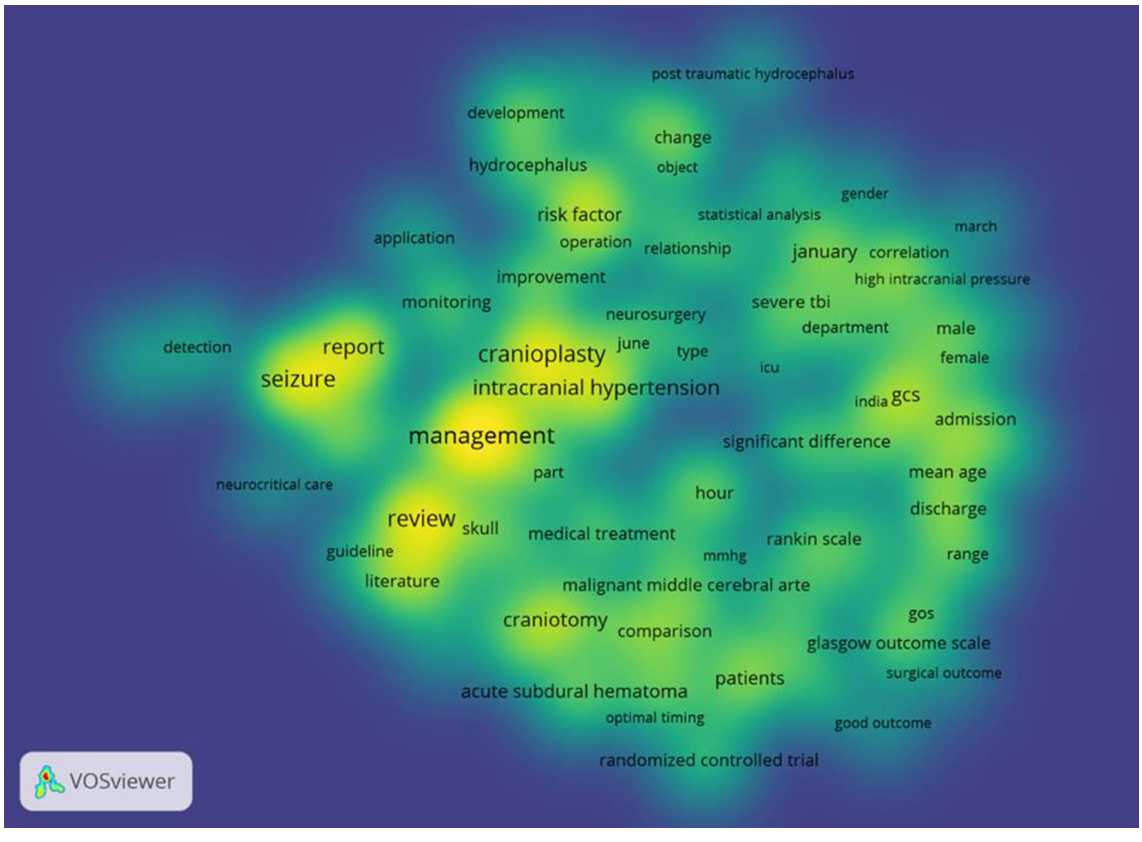

Fig. 4. Research topic intensity and saturation level

shift in focus towards neurological monitoring, patient outcomes, and post-surgical complications, including seizures. These developments highlight opportunities for further research with a continuous EEG monitoring approach, the use of artificial intelligence (AI) for automatic detection, and the relationship between subclinical seizures and long-term functional outcomes.

Discussion

Bibliometric analysis shows that publications on seizure detection in patients after decompressive craniectomy increased between 2015 and 2025. This trend illustrates the growing attention of clinicians and researchers to the problem of neurological complications in the form of seizures that can affect patient outcomes in critical care units. Studies on the use of continuous EEG in the ICU support these findings, as many critically ill patients experience subclinical seizures or non-convulsive status epilepticus that can only be detected with specialised monitoring [17]. Integrated bibliometric findings, covering author productivity, international contributions, methodological characteristics, instruments, and thematic grouping (***Tables 1–3***), provide a comprehensive overview of current research trends in decompressive craniectomy and seizure detection.

Publication patterns show a dominance of developed countries, such as the United States, Europe, and Japan, which have comprehensive neurocritical facilities as summarised in ***Table 3***. Conversely, contributions from developing countries remain limited due to constraints in resources, technology, and research funding. This pattern is consistent with bibliometrics on the topic of epilepsy, where the most numerous and influential publications originate from research centres in developed countries [18, 19].

Keyword analysis using VOSviewer reveals three main clusters: continuous EEG, seizure monitoring, and neurocritical outcome. These clusters emphasise that research is not only focused on seizure identification, but also on early detection efforts and their relationship with patient clinical outcomes as shown in ***Table 1 and 3***. This finding aligns with previous articles emphasising the importance of continuous EEG monitoring to detect non-convulsive seizures and their relationship with neurological outcomes [16, 20-22].

Compared with general TBI literature, publications focusing on decompressive craniectomy reveal distinct thematic patterns (***Table 1***), particularly cortical excitability and postoperative electrophysiology. While seizure risk is inherently linked to the primary brain injury, the DC procedure introduces secondary factors such as dural irritation and hemodynamic shifts which may modulate epileptogenesis. Therefore, bibliometric separation from the broader TBI population is justified to capture these unique research patterns.

The overlay map reveals a shift in research focus from descriptive studies to clinical trials assessing the effectiveness of detection methods, particularly continuous EEG. Whereas previous research mostly described phenomena, more recent publications explore new technologies, including the use of machine learning-based algorithms for automatic seizure detection [23-25].

EEG acquisition in post-craniectomy patients differs technically from conventional scalp EEG due to bone flap removal. The absence of skull attenuation enhances cortical potentials, possibly altering spectral power. Several studies place electrodes near the defect margins, whereas others employe intracranial or hybrid electrode arrays. Such heterogeneity in electrode configuration and montage contributes to methodological variation in seizure detection reports.

In terms of authors and institutions, it is evident that a number of highly productive researchers form centres of excellence in the field of neurocritical care as shown in ***Table 2 and 3***. However, international collaboration in publications remains relatively limited. This presents an opportunity to expand international collaboration to standardise seizure detection worldwide. A similar phenomenon is observed in epilepsy research, where global collaboration remains suboptimal [26-28].

Most publications appear in high-impact journals such as Neurocritical Care and the Journal of Clinical Neurophysiology. Related articles are also found in general neurology and intensive care journals, demonstrating the interdisciplinary nature of this research. One example is a publication in the Journal of Intensive Care highlighting non-convulsive seizures in intensive care unit (ICU) patients [17, 29, 30].

In terms of citations, articles discussing continuous EEG monitoring received the most attention. This is understandable given that subclinical seizures are often not identified through conventional methods. For example, research conducted in patients after brain tumour surgery have proved that non-convulsive seizures are more effectively detected using cEEG.

Temporally, publications increased sharply after 2020, coinciding with the development of bedside monitoring technology and increased clinical awareness of hidden seizures (***Table 2 and 3***). Additionally, there have been more clinical trials and research on new devices that enable real-time seizure detection using dual sensors such as accelerometers and oximeters [13, 16, 31].

However, limitations remain evident. Most publications are retrospective or based on a single research centre, resulting in insufficient external evidence. Multicentre studies with large populations and long-term observations are urgently needed to strengthen the scientific basis regarding the effectiveness of post-surgical seizure detection [32, 33].

Overall, these bibliometric findings confirm that the topic of post-decompressive craniectomy seizure detection is a rapidly developing and clinically important field. Future efforts should focus on enhancing international collaboration, conducting multicentre research, and the use of advanced, accessible technology, especially in developing countries. Evaluations of the effectiveness of detection methods should also consider aspects of sensitivity, specificity, and readiness for implementation in various healthcare settings.

Table 1. Mapping of keyword co-occurrence analysis produced several clusters

Cluster	Main topic	Keyword	Interpretation
Red	Clinical outcome	admission, GCS, discharge, outcome	Focus on the condition of patients admitted to the ICU and outcomes after discharge
Green	Management & Surgery	management, craniotomy, acute subdural hematoma	Management, craniotomy, acute subdural haematoma. Emphasises surgical aspects and critical care management
Blue	Intracranial Pressure	intracranial hypertension, monitoring, risk factor	Related to physiological complications after surgery
Purple	Seizures & Detection	seizure, detection, neurocritical care	Begins to highlight issues of clinical and subclinical seizure detection

Table 2. Mapping the most productive authors

No	Author	Number of publications	Description
1	Honeybul, Stephen	126	Numerous publications related to craniectomy & complications
2	Beucler, Nathan	10	Focus on patient outcomes
3	Kolias, Angelos G.	8	Neurosurgeon, active in DC research
4	Wettervik,Teodor Svedung	7	Focus on neurocritical care & monitoring
5	(others)	5–7	Researchers related to DC management

Table 3. Mapping country with high contributions

No	Country	Number of publications	Main focus	Register of bibliometric
1	United States	32	cEEG, post-craniectomy outcomes, ICU seizures	Highest citation dominance
2	Germany	15	Neurotrauma, detection of seizures after TBI and stroke	Central European collaboration
3	Japan	12	Neurosurgery, post-operative monitoring of brain tumours	Many single-center studies
4	China	11	Non-invasive detection, AI algorithms for seizure detection	Increasing trend since 2020
5	United Kingdom	10	Post-DC neurological prognosis, cEEG monitoring	Focus on clinical trials
6	South Korea	9	Brain trauma, post-DC outcomes with EEG	Active neurotrauma centers
7	Canada	7	Multicenter studies, neurocritical care guidelines	Collaboration with the US
8	Italy	6	Post-stroke and DC neurological outcomes	Focus on functional outcomes
9	France	6	Neurointensive monitoring, post-operative epilepsy	Mixed cohort & trial studies
10	India	5	Limited access to EEG, clinical focus on TBI	Few publications
11	Australia	4	Small ICU & post-brain trauma studies	International collaboration
12	Netherlands	3	Outcome & seizure prediction models	Computational focus
13	Spain	3	Neuroprognosis and post-operative epilepsy	ICU Based studies
14	Turkey	2	Case studies of DC and post-operative seizures	Limited publications
15	Other countries (misc.)	5	Sporadic studies (Sweden, Brazil, Egypt, Iran, Taiwan)	Minor contributions

Conclusion

Although research on decompressive craniectomy has advanced significantly over the past two decades, yet seizure detection remains an understudied area. Increased research in this area is crucial for improving clinical outcomes and guiding evidence-based practice in the critical care management of patients following decompressive craniectomy.

Future research directions

Given the number of studies related to early detection of post-DC seizures, further research is needed. This includes multicenter cohort studies to evaluate the incidence of seizures after DC, the application of advanced EEG techniques and digital biomarkers in seizure detection, and outcome-based studies linking seizure occurrence to functional recovery, clinical trials evaluating seizure monitoring interventions, and consensus guidelines that integrate seizure detection into the DC care pathway.

Declaration of interest

There is no conflict of interest in this study

Acknowledgements

The author would like to thank the Master's Programme in Nursing, Faculty of Health Science, Jenderal Soedirman University for supporting this study.

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