JRMI
Journal of Rehman Medical Institute

Volume 10, No. 4
October - December 2024
www.jrmi.pk

SYSTEMATIC REVIEW

Current advancements in awake craniotomy: a systematic review

Warda Tariq, Hassan Karim, Muhammad Shoaib Khan, Aamir Ajmal, Amjad Ali, Zubair Shams, Sadaf Khan, Eemaz Nathaniel

Submitted
July 19, 2024
Accepted
November 03, 2024

Author Information

From: Rehman Medical Institute, Peshawar, Khyber Pakhtunkhwa, Pakistan

Dr. Warda Tariq
House Officer

Mr. Hassan Karim
Nursing Intern

Dr. Muhammad Shoaib Khan
House Officer

Dr. Aamir Ajmal
House Officer

Dr. Amjad Ali
House Officer

Dr. Zubair Shams
House Officer

Dr. Sadaf khan
House Officer

Dr. Eemaz Nathaniel
Research Officer, Rehman Medical College, Peshawar, Khyber Pakhtunkhwa, Pakistan.
(Corresponding Author)
Email:
eemazoo64@gmail.com

Citation: Tariq W, Karim H, Khan MS, Ajmal A, Ali A, Shams Z, et al. Current advancements in Awake Craniotomy: a systematic review J Rehman Med Inst. 2024 Oct-Dec;10(4):39-44.

ABSTRACT

This study aims to provide insights into the current advancements in Awake Craniotomy procedures, with a focus on Asia. Additionally, it seeks to evaluate the advantages of Awake Craniotomy over traditional methods, such as burr holes, in the treatment of brain tumors.

A systematic review of available data on craniotomies is presented, with only a few exceptions. Given the scarcity of data regarding awake craniotomies in Pakistan, assumptions were made regarding the initial practices. The search encompassed all relevant articles on Awake Craniotomy and anesthesia in Awake Craniotomy.

Keywords: Craniotomy; Brain Neoplasms; Epilepsy; Trepanation; Clinical Hypnosis; Neurosurgery.

The authors declared no conflict of interest. All authors contributed substantially to the planning of research, data collection, data analysis, and write-up of the article, and agreed to be accountable for all aspects of the work.

INTRODUCTION

Awake Craniotomy is a surgical procedure performed under local anesthesia to remove brain tumors, especially those in critical areas, without causing additional neurological deficits.[1] It has ancient roots, with early evidence of similar practices predating general anesthesia. Initially used for seizures and various conditions, modern applications involve mapping and excising lesions in crucial brain regions.[2] Brain mapping, initially for epilepsy, extended to treating malignancies, and has been utilized since the 1980s in North America, Europe, and Asia. Its use of minimal resources and a large patient population in Asia suggest significant potential impact in the region.[3]

Awake Craniotomy for tumor surgery evolved from applications in epilepsy treatment. Archaeological findings indicate trepanation for seizures, possibly related to brain tumors. In the 17th century, modern medicine first used awake craniotomies to treat epilepsy.[3] The poor outcomes of Trepanation led researchers, like John Hughlings Jackson and Charcot, in the 19th century, to explore cerebral localization for understanding seizures. Charcot's emphasis on linking clinical results with pathological findings influenced neurological examination practices.[3]

Charcot's early research led to the development of “system disorders”, advancing clinical neurology with functional neuroanatomy and physiology. In 1861, Broca identified the Broca area in the frontal lobe by studying patients unable to speak but hear language. He discovered eight patients with similar lesions by 1864, attributing language function to the "left hemisphere".[4] Jackson initially believed sensorimotor functions were subcortical but later extended his ideas to specific cortical functions, a fundamental contribution to cerebral localization history. Pioneering work by Broca and Jackson inspired further research into cerebral localization sites.[5]

In 1928, working with Otfrid Foerster, Penfield researched epilepsy causes and surgical treatment, learning Foerster's cortical stimulation technique for removing brain scars from gunshot wounds. Back in Montreal, he applied the technique in awake craniotomies, initially for epilepsy surgery and later for brain tumors, including his sister.[5]

In the 1960s, Penfield and Paquet performed awake craniotomies on epileptic patients, publishing seminal papers on surgical and anesthetic aspects.[6,7] The ongoing assessment of brain structures and functional integrity during Awake Craniotomy, aided by local anesthesia, allows surgeons to prevent injury to essential brain regions, making it crucial in neurological treatments.

Awake Craniotomy is a preferred procedure for lesions near the eloquent cortex, offering advantages like fewer iatrogenic deficits and shorter hospital stays.[8] It allows surgeons to map cortical tissue, enhancing tumor removal with reduced postoperative impairments.

Despite the fact that some patients might be afraid, there are several advantages of undergoing Awake Craniotomy. These include minimization of procedure dangers, fewer ICU admissions, faster recovery duration, and lowering arterial lines and catheters needs over traditional craniotomies done under general anesthesia.[9] Recent advances in technique and anesthetic drugs have made Awake Craniotomy more widely acceptable for various surgeries as an alternative to general anesthesia.[10] However, positive neurological outcomes are important to think about the damage that could happen to subcortical structures during Awake Craniotomy for brain tumors. A recent study in Neurosurgery found that a newly developed “hypno-sedation” approach may be useful to patients undergoing awake surgery for gliomas; Zemmoura and colleagues[11] also reported high hypnosis success rate from their initial experience with 37 patients who underwent awake craniotomies between 2011 and 2015 which were mostly for low-grade glioma. This study reveals potential benefits, especially among those who suffer from advanced brain tumors. The historical context notes the evolution of anesthetic agents, such as cocaine in 1884 and subsequent developments like procaine, lignocaine, prilocaine, and bupivacaine, which paved the way for advancements in neurosurgery, including awake craniotomies.[3]

In 1988, the first study on Awake Craniotomy used local analgesia, intravenous fentanyl, and droperidol. Propofol was introduced in 1992, now a common choice for conscious sedation.[3,12] Methods include monitored anesthesia care and conscious sedation. Midazolam is favored for its amnestic and anxiolytic effects, with low doses showing minimal respiratory depression. Local anesthetic enhances safety by raising the seizure threshold. Recently, propofol and remifentanil are commonly employed.[10]

In Bandung's Hasan Sadikin Hospital, the first conscious craniotomy for a brain tumor was completed.[7] A high-grade glioma on the right frontal lobe affected the patient, a 23-year-old male. Since then, this procedure has been used often in Bandung. It was also introduced to Cirebon in October 2004 and Siloam Hospital, Lippo Karawaci Tangerang, close to Jakarta, in December 2005. Further spread into Asian countries is highly likely and anticipated.[10]

Though a proven effective procedure for a variety of neurosurgical conditions, Awake Craniotomy is not without its drawbacks, mainly in the form of failures and postoperative complications. These have been outlined in excellent papers by Shinoura N et al.,[13] and Serletis D et al.[14]; these include worsening of paresis postoperatively or within one month of surgery, neurological deficits, intraoperative seizures (eloquently described by Nossek E et al.[15]), postoperative hematomas requiring evacuation, and wound complications.

Nevertheless, Awake Craniotomy has proved its place as a highly successful procedure with minimum issues in competent and experienced hands, with many improvements over the years,[16] so that it can even be performed without any sedation, the so called “awake-awake-awake” method[17].

The present review aims to provide an understanding of recent advancements in Awake Craniotomy, with a focus on Asia, and explore its advantages over traditional surgical methods. It seeks to evaluate the benefits offered by Awake Craniotomy and provide insights into its effectiveness in treating brain tumors and other neurosurgical conditions.

REVIEW

MATERIALS & METHODS

Search Strategy

Our search strategy was rigorously developed to encompass the breadth of literature pertaining to Awake Craniotomy. A thorough search was executed across several electronic databases, including PubMed, Scopus, and Web of Science, spanning from their inception to December 2021. In collaboration with a medical librarian, we crafted a search algorithm using a blend of MeSH and free-text terms to capture the diverse nomenclature associated with Awake Craniotomy. Key search terms included "Awake Craniotomy," "Intraoperative Monitoring," "Brain Mapping," and "Anesthesia." To complement this electronic search, we manually reviewed references from pertinent studies and reviews and sought expert opinions to uncover any gray literature or ongoing research.

Selection Criteria

We set explicit inclusion criteria for original research articles on Awake Craniotomy outcomes, anesthesia techniques, and technique evolution. Exclusions were applied to editorials, letters, comments, abstracts from conferences, and case reports with fewer than five subjects. Additionally, non-English publications or studies lacking comprehensive outcome data were omitted. The screening process involved two independent reviewers assessing titles and abstracts, with full text reviews conducted to ascertain study eligibility. Any disagreements were reconciled through discussion or by involving an adjudicating third reviewer.

Data Abstraction

Data extraction from selected studies was done using a standardized form. A subset of the included studies was used to test this form and improve it according to the input given. The essential aspects including study characteristics, participant demographics, details of Awake Craniotomy procedures, anesthesia protocols and clinical outcomes were considered in designing the form. Data extraction involved two reviewers with any inconsistencies being resolved by mutual agreement or referral to third party opinion. This involved extracting author(s),

year of publication, study design, sample size, and major findings. We used validated instruments such as Cochrane Risk of Bias for randomized trials and Newcastle Ottawa Scale for observational studies to assess the methodological quality for each study. This painstaking process guaranteed that after gathering data it was synthesized and further analyzed.

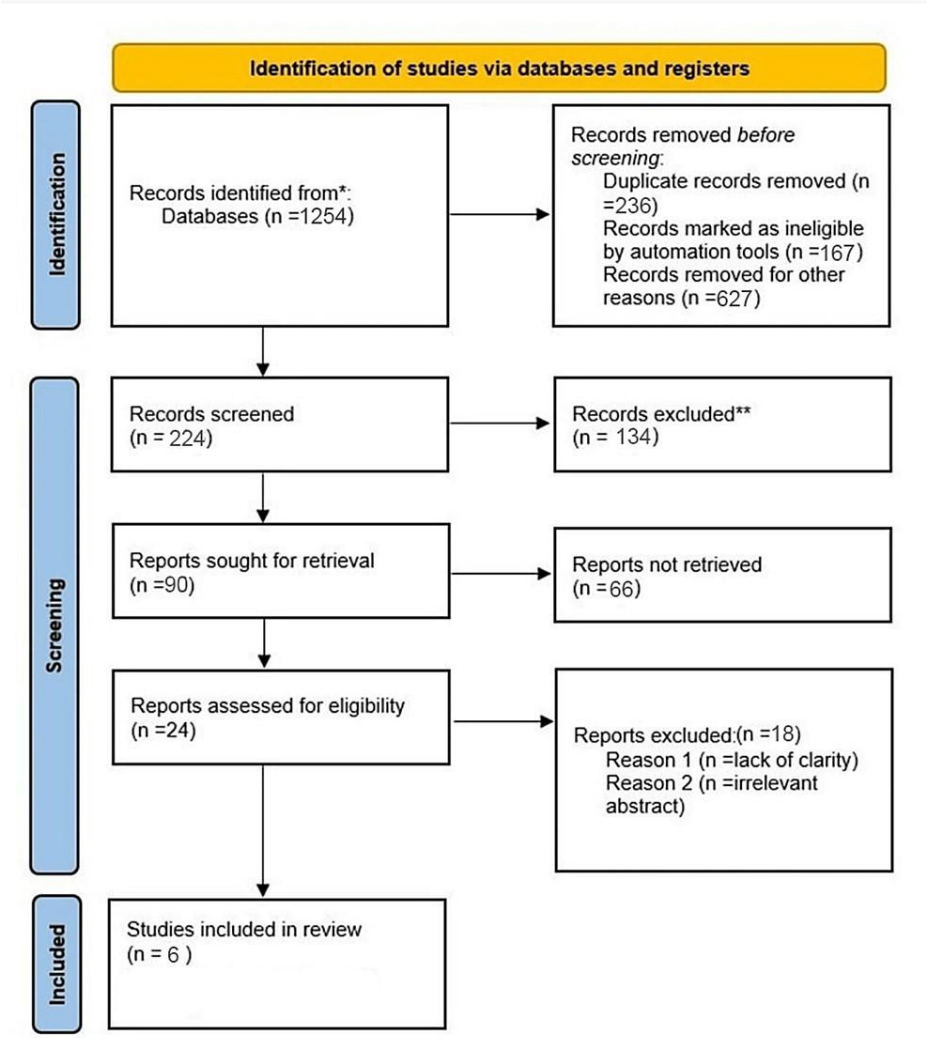

Figure 1: PRISMA diagram detailing the study identification and selection process.

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

RESULTS

Originally, we had 1,254 records at the start of the search. After checking out their titles and abstracts to see if they were related or repeated, we ended up with only 224 after dismissing 1,030 of them. We read through these 224 papers and found that thirty-five met the strict selection criteria. But six major articles captured all the understanding about Awake Craniotomy. This comprised systematic reviews, case reports, comprehensive reviews prospective studies and pilot studies which amounted to a total of eight thousand one hundred fourteen patients.

The selected studies mostly addressed outcomes resulting from Awake Craniotomy. They have considered what techniques of anesthesia are good for use during this procedure and how they have evolved over time. Amongst the first set of investigations there were twenty four about anesthetic protocols. These pieces indicated favorable developments in subject results when specific anesthetic management approaches were used. This is crucial in assisting improved safety and effectiveness through customized anesthesia for Awake Craniotomy.

These were among the six research materials that provided significant insights into both historical changes and present practices regarding Awake Craniotomy in our qualitative synthesis section.

These studies highlighted the critical role of intraoperative stimulation mapping in glioma resections, demonstrated the safety of the procedure in various patient demographics, and explored the psychological impact of the surgery on patients. These findings emphasize the adaptability of the procedure and its capacity to minimize intraoperative discomfort while maximizing postoperative neurological function.

The analysis of the studies that were selected is summarized in Table 1. This table includes the key findings and methodological details of the literature included in this review. The table provides

a concise representation of the significant contributions these studies have made to the field of Awake Craniotomy. It also illustrates the evolution of the practice and its current standing in medical procedures.

TABLE 1: Summary of Included Studies on Awake Craniotomy and Anesthesia Techniques

First Author	Year	Study Design	Study Technique	Study Duration	Sample Size	Inclusion Criteria	Exclusion Criteria	Conclusion
Jooma OV et al. [18]	1951	Case report	Literature systematic review	2018-2021	1 patient	50-year-old right-handed male with first-time complex seizure and emesis	Left-handed male, simple seizure	Awake Craniotomy is safe and effective for lesions in/around eloquent cortex with low post-op deficits
De Witt Hamer PC et al. [19]	2012	Systematic review	Meta-analysis and meta-regression analysis	1990-2010	8,091 adult patients	Adult patients with resective surgery for supratentorial infiltrative glioma, with/without ISM	Young patients with resective surgery for glioma, with/without ISM	ISM in glioma resections is associated with fewer severe deficits, more extensive resection, and is recommended as standard care
Gogos AJ et al. [20]	2020	Comprehensive review	Systematic review	2018-2021 (3 years)	1 patient	History, indications, techniques, outcomes of Awake Craniotomy for glioma	History, indications, techniques, outcomes for non-glioma	Awake Craniotomy with mapping is the gold standard for resection near eloquent brain, with low complication rate
Hejrati N et al. [21]	2019	Prospective study	Standardized questionnaires	Dec 2015-Jan 2018	20 patients	Patients 18-75 years referred for neurosurgery	Patients <18 or >75 years	Post-op psychological symptoms correlate with pre-op symptoms; mental health not negatively affected by AC
Metellus P et al. [22]	2017	Case report	Systematic review	Not specified	1 patient	Deaf right-handed sign language user with seizure	Not specified	Provides evidence of language organization in deaf signers; successful insular glioma removal
Santini B et al. [23]	2012	Pilot study	Data analysis	Not specified	21 patients with brain tumor	Preoperative and intraoperative assessments	Postoperative	

RCT: Randomized Controlled Trial; ISM: Intraoperative Stimulation Mapping; AC: Awake Craniotomy

DISCUSSION

Our review focused on Awake Craniotomy (AC) and included six select articles. It provides valuable insights into the anesthesia used in AC and its history, highlighting significant advancements and findings from these studies. AC has evolved from a primitive trepanation procedure to a sophisticated neurosurgical technique that aims to maximize tumor resection while preserving neurological function.[3,10] The literature we reviewed, although limited, offers a robust comparative analysis of AC's adoption and evolution, reflecting a global perspective.

Throughout history, anesthesia in the medical field has been characterized by continuous innovation and adaptation. The use of cocaine as a local anesthetic in 1884 marked the beginning of modern neuro-anesthesia.[24] However, over the years, various agents such as Propofol, Remifentanil, and Midazolam have been tried in the quest for the optimal anesthetic regimen. Although these agents have been valuable in the past, they have been surpassed by advanced techniques like Asleep-Awake-Asleep (AAA) and Monitored Anesthesia Care (MAC), which offer superior intraoperative patient comfort and surgical outcomes. These advanced techniques have replaced traditional methods and have become the new standard of care.[25]

The procedure of AC has been rapidly integrated into neurosurgical protocols in the Western world due to its numerous benefits. However, in Asia, the adoption of AC has been comparatively slower. The year 2000 was a turning point for AC in Asia as India performed its first procedure in August of that year at the Nizam Institute of Medical Sciences in Hyderabad.[3,7] Subsequently, China and Indonesia also made significant progress in embracing AC as a standard neurosurgical approach.

Pakistan entered the AC arena later, with the first procedure being performed in 2015 at Agha Khan Hospital by Dr. Enam.[1]

The widespread acceptance of AC in Asia underscores its proven efficacy, especially in terms of minimizing complications and speeding up patient recovery.[3] AC's safety and efficiency have made it possible to discharge patients as early as the day after the procedure,[7,8] a remarkable advancement that has a positive impact on the patient's quality of life[26] and healthcare resource utilization. This results in significant cost-effectiveness,[27] making AC a preferred treatment option.

Extensive research has been conducted on the cognitive and psychological impacts of AC. The studies indicate that patients who undergo AC experience less psychological distress and have better postoperative cognitive function than those who undergo traditional craniotomy under general anesthesia.[26,28] This is especially important for surgeries that involve important brain areas where preserving cognitive function is as important as the surgical outcome.

The future of AC in Asia seems bright as ongoing research and training programs are being conducted to improve the technique and broaden its application. Standardized protocols are being developed, and the integration of advanced technologies like intraoperative MRI and neuron navigation is set to further enhance the safety and effectiveness of AC.[29]

The practice of Awake Craniotomy has undergone significant improvement from its initial stages to a more advanced, patient-centered surgical approach. Anesthesia techniques have also evolved over time, and the growing acceptance of AC in Asia highlights the region's commitment to adopting and advancing global neurosurgical practices. With its increasing popularity in Asia, AC is expected to become an integral part of the neurosurgical repertoire, providing patients worldwide with the benefits of this remarkable surgical innovation.

CONCLUSION

Awake Craniotomy is a highly precise neurosurgical procedure that benefits from advanced anesthesia techniques. It has significant advantages, especially in surgeries involving the eloquent cortex. Recently, it has gained recognition and integration in significant healthcare centers in South Asia.

To ensure its future, we must balance technical expertise and patient well-being by embracing a holistic perspective on patient care. We must continue refining the execution of the procedure, recognizing that it encompasses surgical skills and the patient's emotional experience.

REFERENCES

1. Khan SA, Nathani KR, Ujjan BU, Barakzai MD, Enam A, Shafiq F: Awake Craniotomy for brain tumours in Pakistan: an initial case series from a developing country. J Pak Med Assoc. 2016 Oct;66(Suppl 3)(10):S68-S71.
2. Patchana T, Lopez JA, Majeed G, Ho A, Alarcon T, Plantak N, et al. The awake craniotomy: a patient's experience and a literature review. Cureus. 2022 Jun 29;14(6):e26441.
3. July J, Manninen P, Lai J, Yao Z, Bernstein M. The history of awake craniotomy for brain tumor and its spread into Asia. Surg Neurol. 2009 May;71(5):621-4; discussion 624-5. doi: 10.1016/j.surneu.2007.12.022. Epub 2008 May 2.
4. Leblanc R. A Parisian spring: the debate on language localization at the Imperial Academy of Medicine, Paris, April 4–June 13, 1865. Neurosurg Focus. 2019;47(3):E3.
5. Folzenlogen Z, Ormond R. A brief history of cortical functional localization and its relevance to neurosurgery. J Neurosurg. 2019 Sep;47(3):1-8.
6. Bajunaid KM, Ajlan AM. Awake craniotomy. A patient's perspective. Neurosciences (Riyadh). 2015 Jul;20(3):248–252. doi: 10.17712/nsj.2015.3.20140548.
7. Wan Hassan WM. The history of Awake Craniotomy in hospital universiti sains malaysia. Malays J Med Sci. 2013 Oct;20(5):67-9.
8. Blanshard HJ, Chung F, Manninen PH, Taylor MD, Bernstein M. Awake craniotomy for removal of intracranial tumor: considerations for early discharge. Anesth Analg. 2001 Jan;92(1):89-94. doi: 10.1097/00000539-200101000-00018.
9. Taylor MD, Bernstein M: Awake craniotomy with brain mapping as the routine surgical approach to treating patients with supratentorial intra axial tumors: a prospective trial of 200 cases. J Neurosurg. 1999, 90:35-41.
10. Kulikov A, Lubnin A. Anesthesia for Awake Craniotomy. Curr Opin Anaesthesiol. 2018 Oct;31(5):506-510. doi: 10.1097/ACO.0000000000000625.
11. Zemmoura I, Eric Fournier E, El-Hage W, Jolly V, Destrieux C, Velut S. Hypnosis for awake surgery of low-grade gliomas: description of the method and psychological assessment. Neurosurgery. 2016 Jan;78(1):53-61. doi: 10.1227/NEU.0000000000000993.
12. Archer DP, McKenna JMA, Morin L, Ravussin P. Conscious sedation analgesia during craniotomy for intractable epilepsy: a review of 354 consecutives cases. Can J Anaesth. 1988;35(4):338-44.
13. Shinoura N, Midorikawa A, Yamada R, et al. Awake Craniotomy for brain lesions within and near the primary motor area: A retrospective analysis of factors associated with worsened paresis in 102 consecutive patients. Surg Neurol Int. 2013;4:149.
14. Serletis D, Bernstein M. Prospective study of Awake Craniotomy used routinely and nonselectively for supratentorial tumors. J Neurosurg. 2007;107(1):1-6.
15. Nossek E, Matot I, Shahar T, et al. Intraoperative seizures during Awake Craniotomy: incidence and consequences: analysis of 477 patients. Neurosurgery. 2013;73(1):135-140.
16. Bulsara KR, Johnson J, Villavicencio AT. Improvements in brain tumor surgery: the modern history of awake craniotomies. Neurosurg Focus. 2005;18(4):e5.
17. Hansen E, Seemann M, Zech N, Doenitz C, Luerding R, Brawanski A. Awake craniotomies without any sedation: the awake-awake-awake technique. Acta Neurochir (Wien). 2013;155(8):1417-1424.
18. Jooma OV, Pennybacker JB, Tutton GK: Brain abscess: aspiration, drainage, or excision? . J Neurol Neurosurg Psychiatry. 1951, 14(4):308-13.
19. De Witt Hamer PC, Robles SG, Zwinderman AH, Duffau H, Berger MS. Impact of intraoperative stimulation brain mapping on glioma surgery outcome: a meta-analysis. J Clin Oncol. 2012;30(20):2559-2565.
20. Gogos AJ, Young JS, Morshed RA, Hervey-Jumper SL, Berger MS: Awake glioma surgery: technical evolution and nuances. J Neurooncol. 2020, 147(3):515-24.

21. Hejrati N, Spieler D, Samuel R, Regli L, Weyerbrock A, Surbeck W. Conscious Experience and Psychological Consequences of Awake Craniotomy. World Neurosurg. 2019;129:e381-e386.
22. Metellus P, Boussen S, Guye M, Trebuchon A: Successful Insular Glioma Removal in a Deaf Signer Patient During an Awake Craniotomy Procedure. World Neurosurg. 2017, 98:883.e1.-883.e5.
23. Santini B, Talacchi A, Casagrande F, Casartelli M, Savazzi S, Procaccio F, et al. Eligibility criteria and psychological profiles in patient candidates for Awake Craniotomy: a pilot study. J Neurosurg Anesthesiol. 2012 Jul;24(3):209-16.
24. Goerig M, Bacon D, van Zundert A. Carl Koller, cocaine, and local anesthesia: some less known and forgotten facts. Reg Anesth Pain Med. 2012 May-Jun;37(3):318-24. doi: 10.1097/AAP.0b013e31825051f3.
25. Ghazanwy M, Chakrabarti R, Tewari A et al. Awake Craniotomy: A qualitative review and future challenges. Saudi J Anaesth. 2014 Oct-Dec; 8(4):529–539.
26. Fletcher KJ, das Nair R, Macniven JA, Basu S, Byrne P: An interpretative phenomenological analysis of the patient experience of Awake Craniotomy: brain tumour diagnosis to discharge. Br J Health Psychol. 2012,17(4):828-42.
27. Eseonu CI, Rincon-Torroella J, ReFaey K, Quiñones-Hinojosa A: The cost of brain surgery: awake vs asleep craniotomy for perirolandic region tumors. Neurosurgery. 2017, 81(2):307-14.
28. Wrede KH, Stieglitz LH, Fiferna A, et al.: Patient acceptance of Awake Craniotomy. Clin Neurol Neurosurg. 2011;113(10):880-84.
29. Tuominen J, Yrjänä S, Ukkonen A, Koivukangas J: Awake Craniotomy may further improve neurological outcome of intraoperative MRI-guided brain tumor surgery. Acta Neurochir (Wein). 2013; 155(10):1805-12.