INNOVATIVE MINIMALLY INVASIVE APPROACHES IN BRAIN TUMOR SURGERY

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Introduction:
Brain tumors continue to present a significant challenge to modern neurosurgery due to their complex anatomical locations and the vital functions of surrounding brain structures. Traditional open craniotomy, although effective, is associated with considerable risks such as neurological deficits, infection, hemorrhage, and prolonged recovery. As medicine evolves, there has been a paradigm shift toward less invasive techniques that aim to maximize tumor resection while minimizing trauma to the patient. These methods are reshaping neurosurgical practice, making it safer and more precise.

Research Purpose:
This research aims to explore and evaluate the role of innovative minimally invasive techniques in brain tumor surgery. The primary focus is on how these advancements improve surgical precision, reduce patient morbidity, and enhance recovery compared to conventional approaches.

Materials and Methods:
A systematic review was conducted using medical databases and published clinical reports from 2018 to 2024. The analysis included procedures such as neuroendoscopy, keyhole craniotomies, tubular retractor systems, laser interstitial thermal therapy (LITT), awake craniotomy, and stereotactic radiosurgery. Attention was also given to enabling technologies such as neuronavigation systems, intraoperative MRI (iMRI), and fluorescence-guided resection using 5-ALA. Criteria for inclusion emphasized minimally invasive strategies specifically employed for low-grade and high-grade gliomas, meningiomas, and metastatic brain tumors.

Research Results:
Minimally invasive neurosurgical techniques demonstrated numerous clinical advantages. Neuroendoscopy allowed improved visualization and access to ventricular and deep-seated lesions with smaller incisions and faster recovery. LITT

emerged as an option for tumors in eloquent or inoperable areas, enabling thermal ablation without a craniotomy. Keyhole craniotomies, including supraorbital and subtemporal routes, resulted in significantly reduced soft tissue damage and cosmetic concerns. Awake surgeries, combined with cortical mapping, preserved language and motor functions during tumor removal. Intraoperative imaging enhanced resection accuracy and reduced the likelihood of residual tumor. Overall, these approaches decreased hospitalization times, minimized complications, and improved patient satisfaction.

Conclusions:
Minimally invasive brain tumor surgery represents a promising evolution in neurosurgical practice, blending innovation with patient-centered care. These techniques not only reduce surgical risks but also improve functional outcomes and recovery trajectories. As technology advances, the future of brain tumor surgery lies in the integration of real-time imaging, robotics, artificial intelligence, and precision-guided navigation. Embracing these innovations will allow neurosurgeons to treat even the most challenging cases with greater confidence and safety.