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Charting the success of neuronavigation in brain tumor surgery: from inception to adoption and evolution

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Abstract

Purpose: Neuronavigation, explored as an intra-operative adjunct for brain tumor surgery three decades ago, has become globally utilized with a promising upward trajectory. This study aims to chart its success from idea to adoption and evolution within the US and globally.

Methods: A three-pronged methodology included a systematic literature search, impact analysis using NIH relative citation ratio (RCR) and Altmetric scores, and assessment of patent holdings. Data was dichotomized for US and international contexts.

Results: The first neuronavigation publication stemmed from Finland in 1993, marking its inception. Over three decades, the cumulative number of 323 studies, along with the significantly increasing publication trend ($r = 0.74$, $p < 0.05$) and distribution across 34 countries, underscored its progressive and global adoption. Neuronavigation, mostly optical systems (58%), was utilized in over 19,000 cases, predominantly for brain tumor surgery (84%). Literature impact showed a robust cumulative median RCR score surpassing that for NIH-funded studies (1.37 vs. 1.0), with US studies having a significantly higher median RCR than international (1.71 vs. 1.21, $p < 0.05$). Technological evolution was characterized by adjuncts, including micro/exo/endoscope (21%), MRI (17%), ultrasound (10%), and CT (7%). Patent analysis demonstrated academic and industrial representation with an interdisciplinary convergence of medical and computational sciences.

Conclusion: Since its inception thirty years ago, neuronavigation has been adopted worldwide, and it has evolved with adjunct technology integration to enhance its meaningful use. The current neuronavigation innovation pipeline is progressing, with academic and industry partnering to advance its further application in treating brain tumor patients.

Keywords: Brain tumor surgery; Global neurosurgery; Image-guided brain surgery; Neuronavigation; Neurosurgery.

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