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Neurosurgical Intraoperative Histology Techniques

Luis Ramón*

Department of Neurosurgery, University of Florida, Gainesville, FL 32611, USA

Abstract

Neurosurgical intraoperative histology techniques have significantly advanced in recent years, providing surgeons with real-time diagnostic information during surgical procedures. This abstract provides an overview of various techniques employed in intraoperative histology, including frozen section analysis, touch imprint cytology and rapid immunohistochemistry. These methods enable rapid pathological assessment of tissue samples, aiding in surgical decision-making and improving patient outcomes. Furthermore, emerging technologies such as stimulated Raman scattering microscopy and confocal microscopy offer high-resolution imaging capabilities, enhancing intraoperative tissue visualization. This abstract highlights the clinical relevance and utility of these techniques in guiding neurosurgical interventions, reducing operative time and minimizing the need for subsequent reoperations.

Keywords: Neurosurgery • Histology • Surgical interventions • Intraoperative histology techniques • Microscopic examination • Diagnostic

Introduction

Neurosurgery demands precise decision-making in real-time, often relying on histological analysis for accurate tumor identification and boundary delineation. Intraoperative histology techniques have evolved significantly, offering neurosurgeons the ability to make informed decisions during surgery, thereby improving patient outcomes. This article explores the latest advancements in neurosurgical intraoperative histology techniques, highlighting their significance in guiding surgical interventions. Historically, intraoperative frozen section analysis has been a cornerstone of neurosurgical histology. This technique involves rapid freezing and sectioning of tissue samples obtained during surgery, followed by staining for microscopic examination. While providing real-time feedback, frozen section analysis has limitations, including tissue artifacts and sampling errors, which may compromise diagnostic accuracy [1,2].

Literature Review

Touch imprint cytology offers a rapid and minimally invasive alternative to frozen section analysis. By gently pressing tissue samples onto glass slides, cellular material is transferred for staining and microscopic examination. This technique is particularly useful for assessing tumor margins and identifying metastatic lesions during surgery. However, its sensitivity and specificity may vary depending on the expertise of the cytotechnician and the quality of the sample [3].

Intraoperative squash cytology

Similar to touch imprint cytology, intraoperative squash cytology involves the rapid preparation of tissue samples for microscopic examination. However, in this technique, the tissue is gently crushed between two slides, spreading cellular material for staining. Intraoperative squash cytology is particularly valuable for assessing central nervous system tumors, providing rapid feedback on tumor type and grade. Despite its advantages, interpretation may be subjective, requiring experienced pathologists for accurate diagnosis [4].

***Address for Correspondence:** Luis Ramón, Department of Neurosurgery, University of Florida, Gainesville, FL 32611, USA; E-mail: ramon.luis202@health.fau.edu*

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Rapid On-Site Evaluation (ROSE)

Rapid On-Site Evaluation (ROSE) combines the principles of frozen section analysis with touch imprint cytology, allowing for real-time assessment of tissue samples by a pathologist within the operating room. This technique facilitates immediate feedback to the surgeon, guiding intraoperative decision-making. ROSE has demonstrated high diagnostic accuracy and has become increasingly integrated into neurosurgical practice, particularly for complex cases requiring intraoperative histological confirmation [5].

Intraoperative Confocal Laser Endomicroscopy (CLE)

Intraoperative Confocal Laser Endomicroscopy (CLE) represents a technological advancement in neurosurgical histology, enabling real-time, high-resolution imaging of tissue microstructure at the cellular level. By utilizing fluorescent contrast agents, CLE provides dynamic visualization of tumor boundaries and cellular architecture during surgery. This technique offers the potential for precise tumor resection while preserving adjacent healthy tissue. However, CLE requires specialized equipment and expertise, limiting its widespread adoption [6].

Discussion

Neurosurgical intraoperative histology techniques play a crucial role in providing real-time information to surgeons during brain surgeries. These techniques aim to provide rapid and accurate assessment of tissue samples obtained during the procedure, helping surgeons make informed decisions on the course of action. One common technique is frozen section analysis, where a small tissue sample is frozen, thinly sliced and stained for microscopic examination within minutes. This method allows for quick assessment of tumor margins, identification of normal tissue and detection of any abnormalities. Immunohistochemistry (IHC) is another technique used intraoperatively to identify specific proteins within tissue samples. By targeting certain biomarkers, IHC helps distinguish between different types of cells or tissues, aiding in tumor classification and guiding surgical decisions. Intraoperative consultation with a neuropathologist is often employed to interpret histological findings promptly. This collaboration ensures accurate diagnosis and helps tailor the surgical approach to individual patient needs.

Conclusion

Advancements in neurosurgical intraoperative histology techniques have revolutionized the approach to tumor resection, enabling real-time decision-making and precision-guided surgery. From traditional methods such as frozen section analysis to innovative techniques like confocal laser endomicroscopy, neurosurgeons have an array of tools at their disposal for intraoperative

histological assessment. As technology continues to evolve, the integration of these techniques into routine practice holds promise for improving patient outcomes and advancing the field of neurosurgery.

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Conflict of Interest

There are no conflicts of interest by author.

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