Comparing the polarimetric properties of fresh and preserved brain tissue

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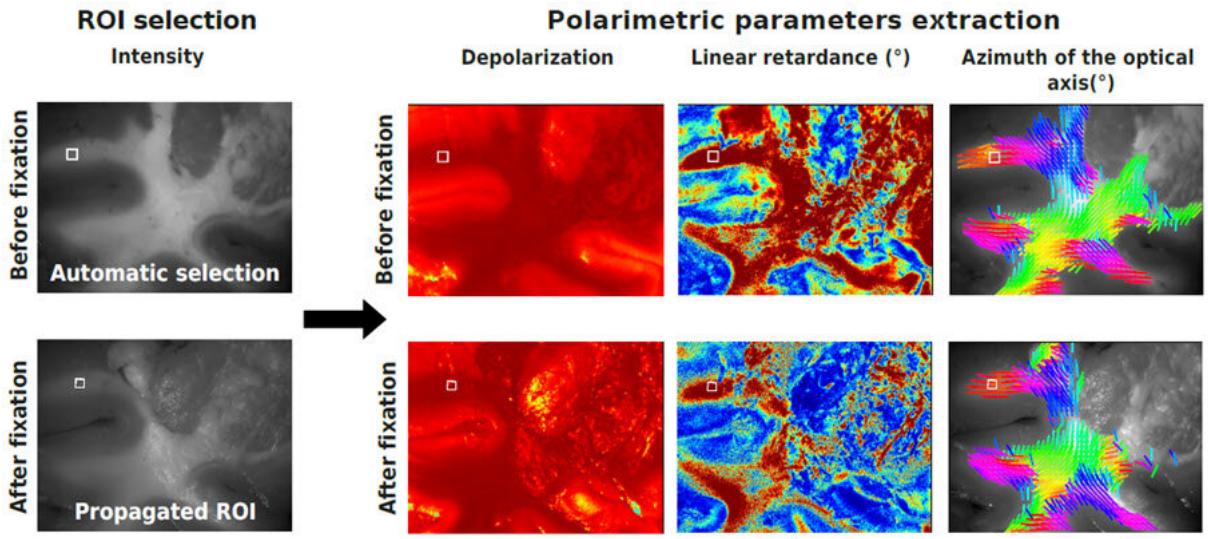

While preserving brain tissue samples in formalin slightly alters their polarimetric properties, they are still similar to those of fresh samples, making them suitable for training machine learning models. Credit: Gros et al., doi 10.1117/1.NPh.10.2.025009.

Gliomas are a group of tumors that originate from glial cells (non-neuronal cells) in the central nervous system and are characterized by diffuse infiltrative cell growth. They can spread quickly throughout the brain and spine by infiltrating nearby tissues, making surgical removal the only viable treatment strategy. Accurate differentiation of the

healthy and the diseased tissue with the help of specialized imaging techniques and modalities is thus important for surgery.

Wide-field Imaging Mueller polarimetry (IMP) is one such approach that uses light polarization to determine the boundaries of different tissue types in a sample. Previous studies have shown that IMP is a promising approach for brain imaging. In particular, IMP can more effectively differentiate between gray and white matter as well as determine nerve fiber orientation, when coupled with machine learning (ML) algorithms.

Furthermore, high-quality rapid diagnostic imaging with such imaging modalities could become possible with the use of ML models. Trained with sufficient IMP data, they could help surgeons automatically analyze brain images to discern and delineate important information, such as pathological zones and neoplastic regions, in real time.

However, obtaining enough fresh human brain tissue samples for training such image processing ML algorithms is extremely difficult. The issue is typically circumvented by training ML models on tissue samples preserved in formalin (aqueous solution of formaldehyde), which helps extend their shelf lives. But it has been unclear whether the polarimetric properties of the formalin-fixed brain tissue are the same as those of the fresh brain tissue.

Addressing this knowledge gap, a team of scientists from Switzerland and France have now characterized the extent of changes in polarimetric properties caused by formalin fixation of brain tissue samples. The study was led by Romain Gros, a Ph.D. student at the University of Bern, Switzerland, and was reported in *Neurophotonics*.

The team established a model using animal brain tissue, extracting 30 tissue sections, each 3 cm thick and containing both gray and white

matter. They performed IMP on these fresh samples using a custom setup. Immediately after each measurement, the fresh sample was fixed in formalin; the researchers then performed IMP on these formalin-fixed samples multiple times over the course of a week. This enabled them to study the changes in the polarimetric properties of brain tissue samples over time following formalin fixation.

Following quantitative analyses of their data, the researchers observed that formalin fixation did not cause radical changes in the polarimetric properties of the brain tissue. Specifically, the mean value of the depolarization of light increased by only 5 percent in the gray matter region and remained roughly the same in the white matter region.

Moreover, they found that the linear retardance, a measure of "desynching" of the different polarization components after passing through the tissue, decreased in almost equal proportions in both the white and gray matter after fixation. Thus, the visual contrast between gray and white matter remained unchanged. In addition, the ability to visualize brain fiber orientations remained intact after formalin fixation.

Further, despite observing a noticeable shrinkage of the tissue, the researchers found that it did not significantly affect the width of the "uncertainty region," the area within a sample where the polarimetric properties do not allow for a clear distinction between white and gray matter.

Together, these findings suggest that formalin-fixed brain tissue samples, in the context of polarimetry, are as good as fresh tissue samples, and are thus suitable for training ML models. Given the ease of obtaining formalin-fixed brain tumor samples over fresh samples, these findings can facilitate the design and training of tumor segmentation algorithms.

More information: Romain Gros et al, Effects of formalin fixation on

polarimetric properties of brain tissue: fresh or fixed?, *Neurophotonics* (2023). DOI: 10.1117/1.NPh.10.2.025009