Non-negative matrix factorization for differentiation of brain metastasis and glioblastoma multiforme, and visualization of tumor infiltration

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Introduction – This study focuses on the differentiation between solitary brain metastasis and glioblastoma multiforme based on conventional magnetic resonance imaging (MRI) and two-dimensional turbo spectroscopic imaging (2D-TSI) data. The infiltrative nature of glioblastoma multiforme has been further investigated by using non-negative matrix factorization (NNMF) [1, 2].

Materials and methods – Fifteen patients with a brain tumor, nine affected by glioblastoma multiforme and six by metastasis, were considered in this study. The data were acquired with 1.5 T Philips magnets (Philips Medical Systems, The Netherlands) at the Radiology Service of Clínica Quirón, and the Hospital La Ribera, Alzira, Valencia (Spain), as a part of the routine clinical preoperative MRI and spectroscopy protocol for the brain and using eTUMOUR FP6 project protocols [3]. High-resolution MRI (T1-weighted pre- and post-gadolinium injection) and T2-weighted images) data were acquired prior to the 2D-TSI study (24x24, TE = 272 ms, TR = 2000 ms, FOV = 230x230 mm, slice thickness = 20 mm, 256 points). Each volume unit dimension was 9.6x9.6x20 mm (1.8 ml). Data processing included zero filling to 512 points, water removal by using HLSVD-PRO, Fourier transformation, peak integration of NAA, Cr and Cho. For each patient 2D-TSI voxels were assigned to three groups by radiologists: non-T2 hyperintense/non-enhancing, perienhancing and enhancing tumor. Furthermore, two constituent vectors of length 3 were extracted from each patient's 2D-TSI data using NNMF. These constituents correspond to a normal component and a tumor component, respectively.

Results and conclusion – Figure 1 shows a scatter plot (Cho/Cr versus Cho/NAA) of the difference of the patients' averaged ratio in the enhancing tumor and the non-T2 hyperintense/non-enhancing area. Glioblastomas and metastases form two separated clusters, the latter having smaller ratio values. Figure 2 provides a scatter plot of the result of automated processing with NNMF. The horizontal axis corresponds to the difference between the ratio element3/element2 of the tumor component and the normal component. Similarly, the vertical axis depicts this difference measure for element3/element1. The NNMF approach results in a clear separation of glioblastomas and metastases. Figures 3 and 4 visualize the abundances of the normal component that is obtained with NNMF for two cases with glioblastoma multiforme. These abundances indicate tumor infiltration. In conclusion, the use of 2D-TSI enables to visualize metabolic differences between glioblastomas and metastases. Automated processing with NNMF allows differentiation of these tumors and enables to visualize tumor infiltration.