

Triple-layer Appearance of Human Cerebral Cortices on Phase-Difference Enhanced Imaging using 3D Principle of Echo Shifting with a Train of Observations (PRESTO) Sequence

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Purpose: The laminar patterns in the human cerebral cortices are a basis for the classification of the cytoarchitectonic areas (Brodmann areas). These patterns were visualized on formalin-fixed specimens at 9.4T MRI (1). However, they have not been investigated at 3T MRI in living humans. MR imaging using phase information has been reported (2,3). We developed a novel technique of phase-difference enhanced (PADRE) imaging to enhance a phase difference of tissue structures. The PADRE imaging technique uses three-dimensional (3D) principle of echo shifting with a train of observations (PRESTO) which allows high-resolution phase estimates. The purpose of this study was to determine whether the cerebral cortices in living humans exhibit different laminar patterns on PADRE imaging at 3 T.

Materials and Methods: We evaluated axial 1-mm-thick PADRE images obtained using an 8-channel head coil and a 3T MR scanner (Philips, Achieva, Best, the Netherlands) in 6 healthy volunteers (5 males and 1 female; age range 24–43 years; mean age 31 years). The sequence was performed with a TR of 31 ms, TE of 50 ms, FA of 10°, FOV of 23 x 23 cm, and a matrix of 512 x 512. The acquisition time was approximately 11 minutes. We adjusted parameters of PADRE imaging using high-pass filter and phase enhancement techniques in order to enhance the laminar patterns of the cortices. The triple-layer appearance (outer hyperintense, middle hypointense, and inner hyperintense layers) in the superior frontal gyrus, primary motor cortex, primary sensory cortex, primary visual cortex, primary auditory cortex, and superior parietal gyrus was graded independently by 2 experienced neuroradiologists as definitely present (grade 3), probably present (grade 2), or definitely absent (grade 1). Final interpretation was performed by consensus. Interobserver agreement was assessed by k statistics.

Results: In 6 cases a triple-layer appearance of grade 3 or 2 was seen in all bilateral primary motor, sensory, and visual cortices (Figs 1 and 2). In 83% and 33%, respectively, the appearance of the primary auditory cortex and superior parietal gyrus was recorded as grade 3 or 2. In the superior frontal gyrus, all cortices were classified as grade 1. Interobserver agreement was excellent ($k = 0.93$).

Conclusion: On PADRE images using PRESTO sequence at 3T, the triple-layer appearance of the eloquent cerebral cortices frequently seen in healthy volunteers. The triple-layer appearance on PADRE imaging is a novel marker of the eloquent cerebral cortices and may be useful for the preoperative identification of the cortices.

References:

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2. Rauscher A, et al. Magn Reson Med. 2005;54:87-95.
3. Zhong K, et al., NeuroImage 2008;40:1561-1566..

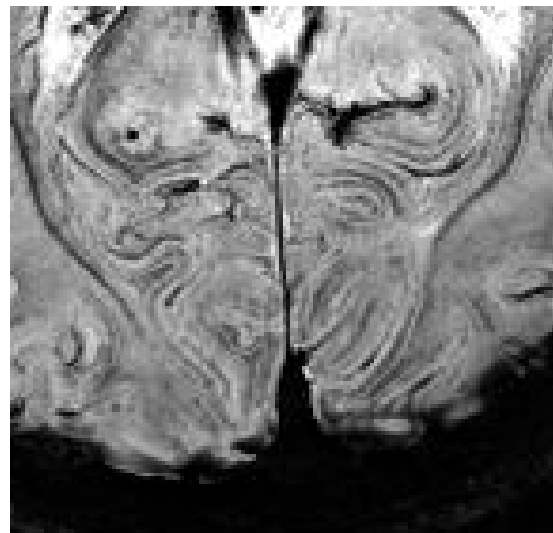
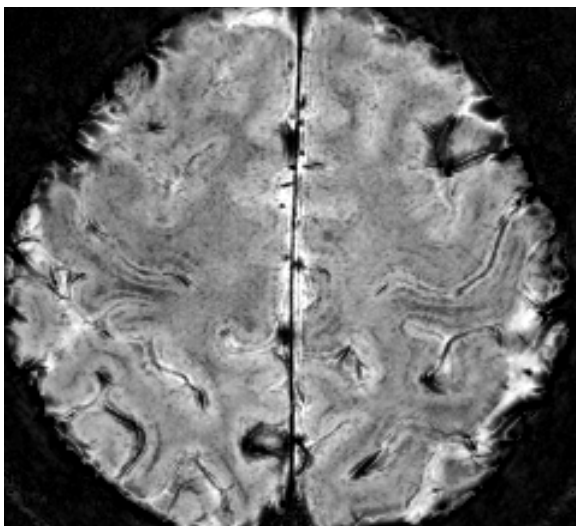


Fig 1. PADRE image at the level of the central sulcus. Fig 2. PADRE image at the level of the visual cortex.