Patterns of Cortical Myelination Are Intact in Lower Limb Amputees

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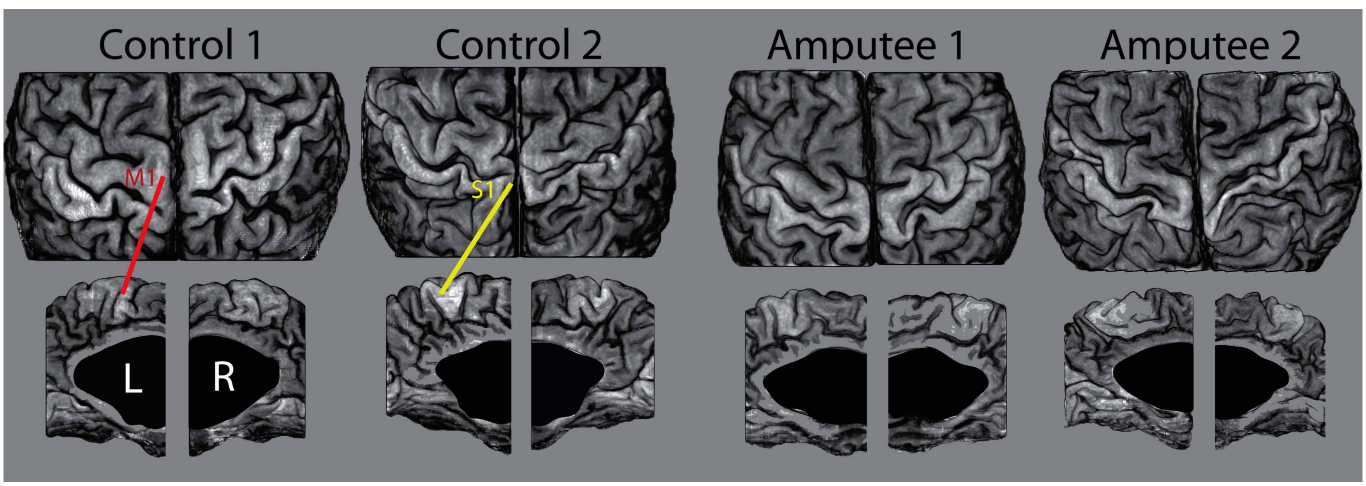
An emerging technique to investigate the structural organization of the human cortex is to image its pattern of myelination using high resolution anatomical imaging[1,2,3]. We used this technique in a study of cortical plasticity to investigate whether the loss of a lower limb results in a change in the pattern of strong cortical myelination in either the primary motor (M1) or somatosensory cortices (S1).

Methods: Imaging was performed in four male volunteers: two lower limb amputees who lost their limbs as a result of trauma and two age-matched controls (see Table). None of the subjects had neurological conditions. The experiments were approved by the Research Ethics Board at Saint Joseph's Hospital. Subjects were imaged using a T_1-weighted protocol optimized for visualizing cortical myelin[4] on a 3 Tesla General Electric scanner (Ver. 22.0) with a 32-channel receive-only head coil (MR Instruments). A slab-selective, 3D T_1-weighted inversion-recovery sequence with 0.7 mm isotropic resolution was acquired over M1 and S1. This image was divided by a steady-state 3D FLASH image with little T_1-weighting to remove B_1^- inhomogeneities. The brain was segmented from the resulting ratio image and displayed in the software Amira using the Voltex function. In this view, strongly myelinated regions of the cortex appear bright.

Results and Discussion: Both control and amputee images showed strong bilateral image enhancement in the area of M1 and S1 in the medial longitudinal fissure representing the knee, ankle, and toes. This suggests that in the amputees, the axons projecting from M1 to the spinal cord for the affected limb are intact. The same holds true in S1, where the original afferent axons may be present for the affected limb. This lack of evidence of structural cortical plasticity has a precedent; a previous study found that a heavily myelinated feature of the primary visual cortex, the Stripe of Gennari, is present in congenitally blind individuals[5]. In our study, however, the enhancement could also be the result of new axonal connections being made in M1 and S1 to represent other anatomical locations.



Subject	Sex	Age	Lost Limb	Age at Loss
Control 1	M	50	-	-
Control 2	M	64	-	-
Amputee 1	M	72	Left, below knee	7
Amputee 2	M	49	Right, below knee/Right, above knee	10/45

Dorsal (top) and medial wall (bottom) views of the cortex. The red line indicates primary M1 in the region of the lower leg in one subject. The yellow line indicates S1 in the region of the lower leg.

References:
1Glasser et al., J Neurosci 2011; 13: 31:11597-11616.
2 Cohen-Adad et al., 2012; Neuroimage 60:1006-10014.
3 Sereno et al., 2012; Cerebral Cortex Epub before print.
4 Bock et al., 2013; NeuroImage 65: 1-12.
5 Trampel et al., 2011; Cerebral Cortex, (9):2075-81.