Seminars in
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Functional and Dysfunctional Sensorimotor Anatomy and Imaging

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The sensorimotor system of the human brain and body is fundamental only in its central role in our daily lives. On further examination, it is a system with intricate and complex anatomical, physiological, and functional relationships. Sensorimotor areas including primary sensorimotor, premotor, supplementary motor, and higher order somatosensory cortices are critical for function and can be localized at routine neuroimaging with a familiarity of sulcal and gyral landmarks. Likewise, a thorough understanding of the functions and dysfunctions of these areas can empower the neuroradiologist and lead to superior imaging search patterns, diagnostic considerations, and patient care recommendations in daily clinical practice. Presurgical functional brain mapping of the sensorimotor system may be necessary in scenarios with distortion of anatomical landmarks, multiplanar localization, homunculus localization, congenital brain anomalies, informing diffusion tensor imaging interpretations, and localizing nonvisible targets.
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Introduction

A thorough understanding of sensorimotor anatomy and dysfunction is a desirable standard for the practicing neuroradiologist. Functional anatomy and deficit locations can be readily identified by using sulcal and gyral landmarks. These landmarks are critical in understanding and localizing the functional topography of primary sensorimotor, premotor, supplementary motor, and higher order somatosensory cortex. In addition to obvious functional deficits such as contralateral weakness and basic sensory dysfunctions, neuroradiologists should be able to localize higher order deficits of the sensorimotor system. An understanding of deficits and functional localization can affect diagnostic search patterns, imaging diagnoses, and imaging recommendations in patients with stroke, tumor, and other conditions. Understanding the functional correlates of blood oxygen level dependent (BOLD) functional magnetic resonance imaging (fMRI) activation is important in applying the technique clinically as well. In short, an understanding of the sensorimotor system can improve diagnostic accuracy at cross-sectional imaging and functional brain mapping. The following discussion addresses functional and dysfunctional anatomy of primary and higher order sensorimotor systems, related activation patterns, and brain mapping applications. Specific areas discussed include primary sensorimotor, premotor, supplementary motor, and secondary somatosensory, and posterior parietal somatosensory cortices. The reader may be surprised as to the complexity and intricacy of seemingly elementary sensorimotor functions. Tertiary networks involved in sensorimotor processing, including association, basal ganglia, thalamic, and cerebellar networks, are not fully elucidated as they are beyond the scope of this article. Cortical and subcortical substrates of cranial nerve function are discussed in the article of the same name by Agarwal et al and will not be covered here.

Sensorimotor Sulcal and Gyral Anatomy

The key to localizing motor system anatomy is an understanding of regional sulcal anatomy (Fig. 1).[1] Sulcal anatomical

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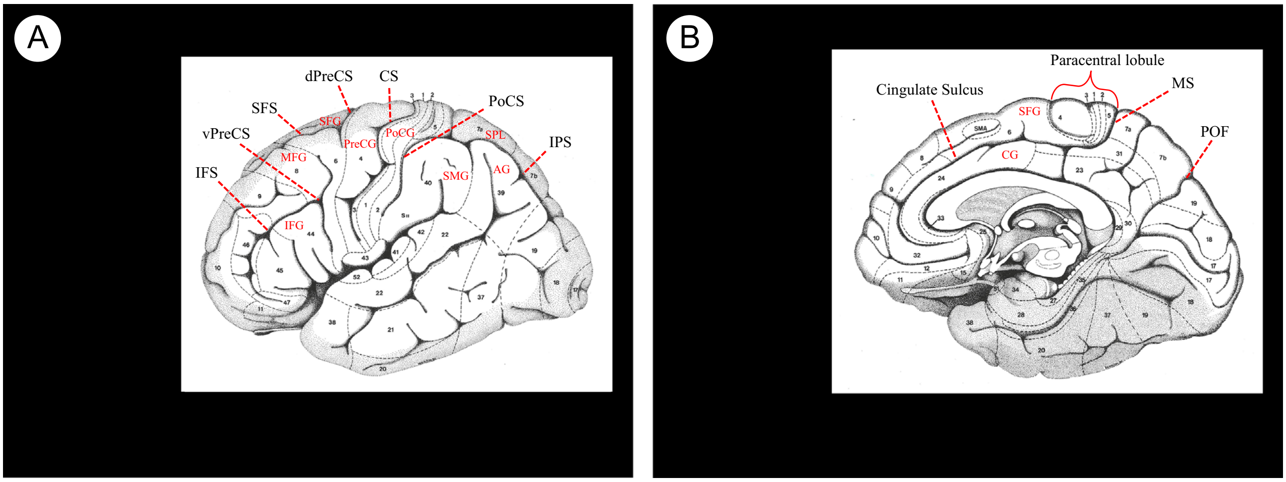

Figure 1 Lateral and medial view surface illustrations of the brain designating important sulcal and gyral landmarks and Brodmann area numbering. AG, angular gyrus; CG, cingulate gyrus; CS, central sulcus; dPreCS, dorsal precentral sulcus; IFG, inferior frontal gyrus; IFS, inferior frontal sulcus; IPS, intraparietal sulcus; MFG, middle frontal gyrus; MS, marginal sulcus; PoCG, postcentral gyrus; PoCS, postcentral sulcus; POF, parietooccipital fissure; PreCG, precentral gyrus; SFG, superior frontal gyrus; SFS, superior frontal sulcus; SMG, supramarginal gyrus; SPL, superior parietal lobule; vPreCS, ventral precentral sulcus. (Modified with permission from Duvernoy.[1]) (Color version of figure is available online.)

landmarks at imaging are more reproducible across patients than gross localization at surgery. This is because the major sulci used to define motor anatomy extend deeper into the brain than do minor sulci, which are more variable and less identifiable at cross-sectional imaging. Sulcal variations exist, but rarely involving all the relevant landmarks. Also, outside of significant brain anomalies, sulcal landmarks are mirrored across hemispheres. Thus, combining landmark data and comparing across hemispheres provides a reproducible methodology to define functional sensorimotor gyral landmarks.

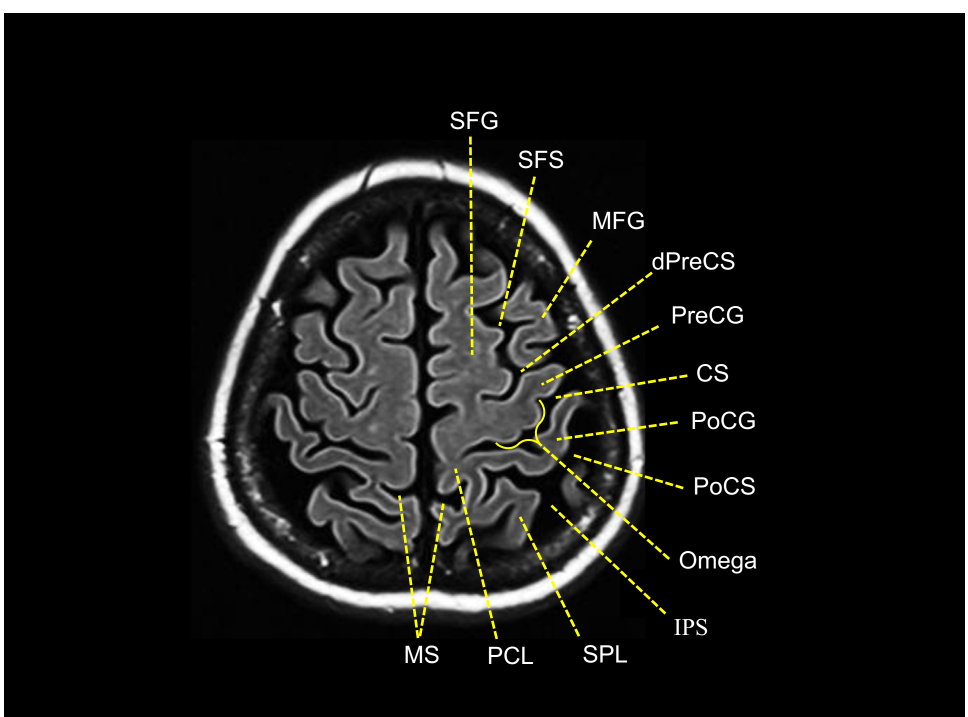

Figure 2 Axial FLAIR image showing landmarks helpful in identifying the central sulcus and sensorimotor anatomy. CS, central sulcus; dPreCS, dorsal precentral sulcus; FLAIR, fluid-attenuated inversion recovery; IPS, intraparietal sulcus; MFG, middle frontal gyrus; MS, marginal sulcus; PCL, paracentral lobule; PoCG, postcentral gyrus; PoCS, postcentral sulcus; PreCG, precentral gyrus; SFG, superior frontal gyrus; SFS, superior frontal sulcus; SPL, superior parietal lobule; Omega: omega shaped along the posterior bank of the precentral gyrus approximates the distal upper extremity MI. (Color version of figure is available online.)