College of Human Medicine
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An MRI-Based Craniometric Framework for Teaching Cortical Surface Localization

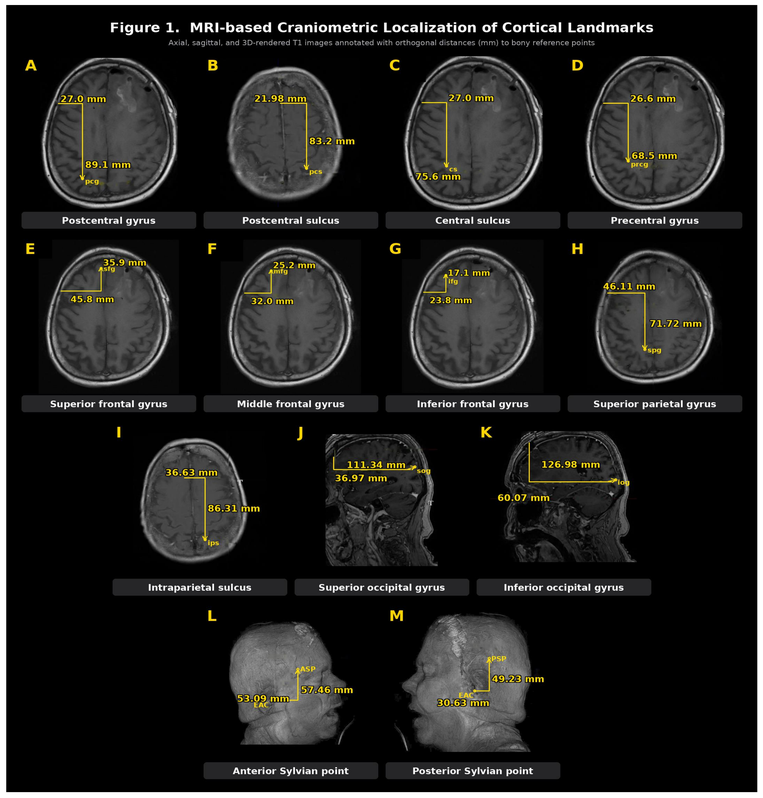
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Introduction

- External landmark localization of cortical anatomy has guided neurosurgical training and craniotomy planning since the 19th century.
- Cranial "key points" reduce bone exposure and improve precision, but existing cadaveric and imaging frameworks remain hard to apply to variable anatomy.
- Neuronavigation is often unavailable in low-resource settings, is an adjunct, not a substitute, for anatomic knowledge, and degrades with brain shift.
- Cadaver models suffer formalin-fixation shrinkage that distorts native in vivo geometry.
- Establish reproducible MRI-based coordinates for 18 cortical and sulcal structures relative to three palpable references: the coronal suture, external auditory canal (EAC), and zygomatic arch.
- Provide a practical, teachable tool for pre-craniotomy localization and minimal-exposure approaches.

Table 1. MRI-derived surface coordinates of 18 cortical and sulcal structures relative to three palpable bony landmarks (coronal suture, external auditory canal, and zygomatic arch). Values are mean ± SD in centimeters across six hemispheres (n = 6). Direction codes: A, anterior; P, posterior; M, medial; S, superior; I, inferior — relative to each region's reference landmark.

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Structure	Reference	Coordinate 1: mean ± SD (SEM), cm	Coordinate 2: mean ± SD (SEM), cm
Perirolandic / central (reference: coronal suture)			
Central sulcus	Coronal suture	Posterior 6.93 ± 1.04 (0.43)	Medial 2.47 ± 0.16 (0.07)
Precentral gyrus	Coronal suture	Posterior 6.26 ± 0.89 (0.36)	Medial 2.47 ± 0.16 (0.07)
Precentral sulcus	Coronal suture	Posterior 5.73 ± 0.90 (0.37)	Medial 2.47 ± 0.16 (0.07)
Postcentral gyrus	Coronal suture	Posterior 7.78 ± 1.09 (0.45)	Medial 2.47 ± 0.16 (0.07)
Postcentral sulcus	Coronal suture	Posterior 8.03 ± 0.92 (0.38)	Medial 2.47 ± 0.16 (0.07)
Frontal (reference: coronal suture)			
Inferior frontal gyrus	Coronal suture	Anterior 1.53 ± 0.55 (0.23)	Medial 1.81 ± 0.34 (0.14)
Middle frontal gyrus	Coronal suture	Anterior 2.32 ± 0.65 (0.26)	Medial 2.83 ± 0.28 (0.11)
Superior frontal gyrus	Coronal suture	Anterior 3.05 ± 0.75 (0.31)	Medial 3.78 ± 0.64 (0.26)
Parietal (reference: coronal suture)			
Superior parietal gyrus	Coronal suture	Posterior 7.75 ± 1.15 (0.47)	Medial 4.30 ± 0.29 (0.12)
Intraparietal sulcus	Coronal suture	Posterior 8.12 ± 1.12 (0.46)	Medial 4.30 ± 0.29 (0.12)
Temporal (reference: zygomatic arch, single vertical line)			
Superior temporal gyrus	Zygomatic arch	Posterior 1.55 ± 0.15 (0.06)	Superior 2.67 ± 0.24 (0.10)
Middle temporal gyrus	Zygomatic arch	Posterior 1.55 ± 0.15 (0.06)	Superior 1.37 ± 0.16 (0.07)
Inferior temporal gyrus	Zygomatic arch	Posterior 1.55 ± 0.15 (0.06)	At arch level
Occipital (reference: coronal suture)			
Superior occipital gyrus	Coronal suture	Posterior 11.20 ± 0.88 (0.36)	Inferior 4.67 ± 0.61 (0.25)
Inferior occipital gyrus	Coronal suture	Posterior 11.68 ± 1.00 (0.41)	Inferior 6.40 ± 0.88 (0.36)
Deep / opercular (reference: external acoustic canal)			
Insula	EAC	Medial 3.04 ± 0.39 (0.16)	Superior 5.27 ± 0.19 (0.08)
Anterior sylvian point (ASP)	EAC	Anterior 5.27 ± 0.38 (0.16)	Superior 4.48 ± 0.64 (0.26)
Posterior sylvian point (PSP)	EAC	Posterior 3.82 ± 0.78 (0.32)	Superior 6.05 ± 0.77 (0.31)

Methods

- Retrospective, IRB-approved MRI study (University of Michigan-Sparrow).
- Six patients, one hemisphere each, contralateral to any intracranial pathology; T1- and T2-weighted sequences.
- Three palpable references (coronal suture, EAC, zygomatic arch), chosen for reliable intraoperative identification.
- Eighteen structures across six regions localized as two-component vectors (cm) along the scalp/skull surface (**Figure 1**).
- Mean, standard deviation (SD), and standard error (SEM) computed across the six hemispheres

Results

- All 18 structures fell within the ~2 cm centering margin (SD ≤ 1.15 cm, SEM ≤ 0.47 cm) **(Table 1)**.
- Mediolateral and zygoma-referenced superior distances were most reliable; anteroposterior distances along the convexity were most variable.
- Precision meets or exceeds classical cadaveric/topographic localization, while avoiding fixation artifact.

Conclusions

- A three-reference scheme centers a craniotomy within accepted margins for most structures.
- Mediolateral and zygoma-referenced superior coordinates are highly reproducible; long anteroposterior measures need wider margins.
- In vivo MRI avoids fixation artifact and preserves true anatomic geometry.
- Simple, teachable, and navigation-free best as centering guides, not intraoperative localizers.