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Temporal Lobe Functional Anatomy : The Surgical Point of View

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Learning Objectives

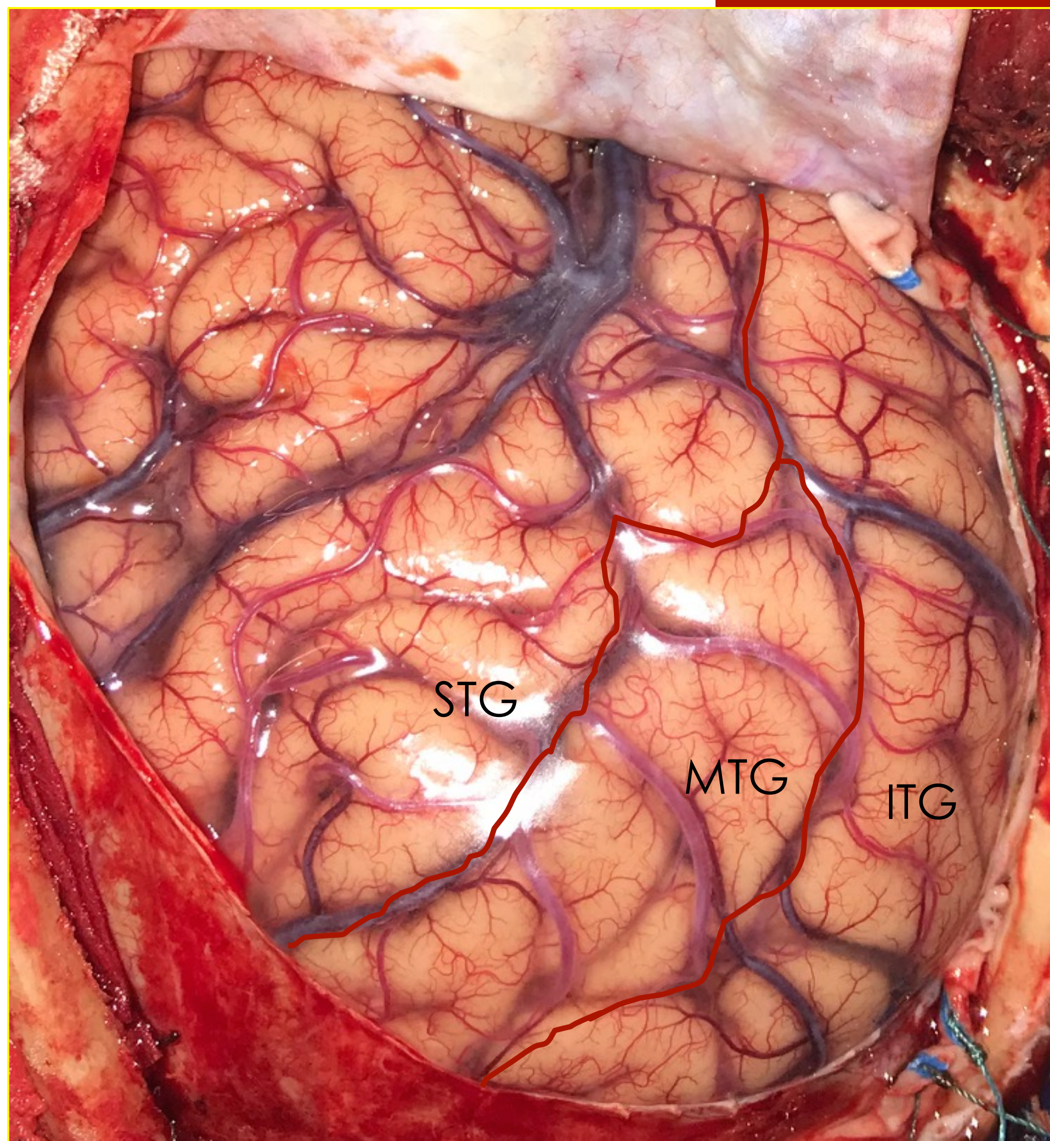
- Necessity of paving a new way of approaching the temporal lobe anatomy
- Morphological anatomy
- Functional anatomy
- Applied temporal lobe anatomy: Surgical considerations

Morphological Anatomy

- The temporal lobe is defined by the Sylvian fissure (inferior to that) on the lateral hemisphere surface

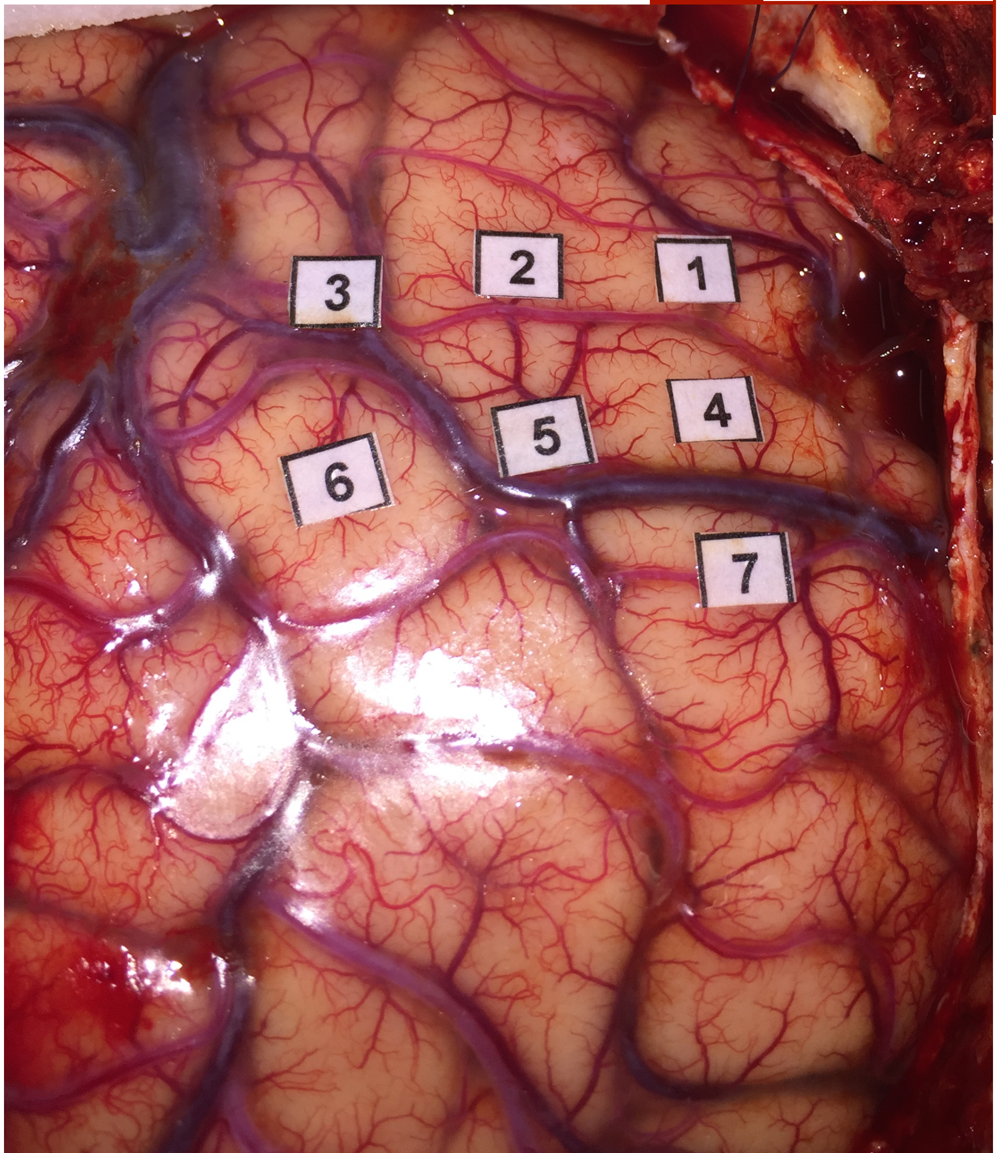
Morphological Anatomy

- The lateral surface of the temporal lobe is divided by the superior and the inferior sulci to: the superior, the middle, and the inferior gyri.



Morphological Anatomy

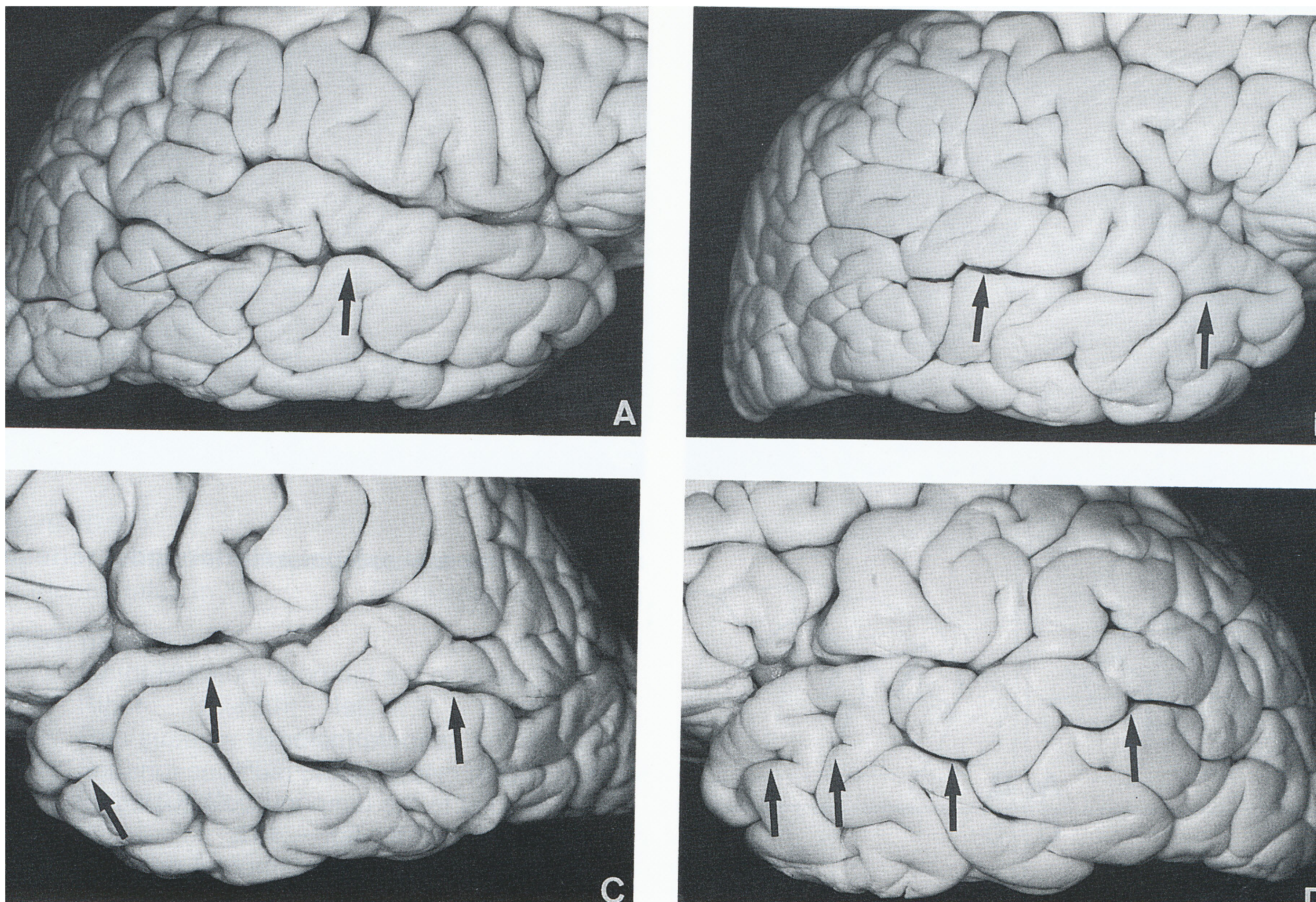
- The lateral surface of the temporal lobe is divided by the superior and the inferior sulci to: the superior, the middle, and the inferior gyri.



Morphological Anatomy

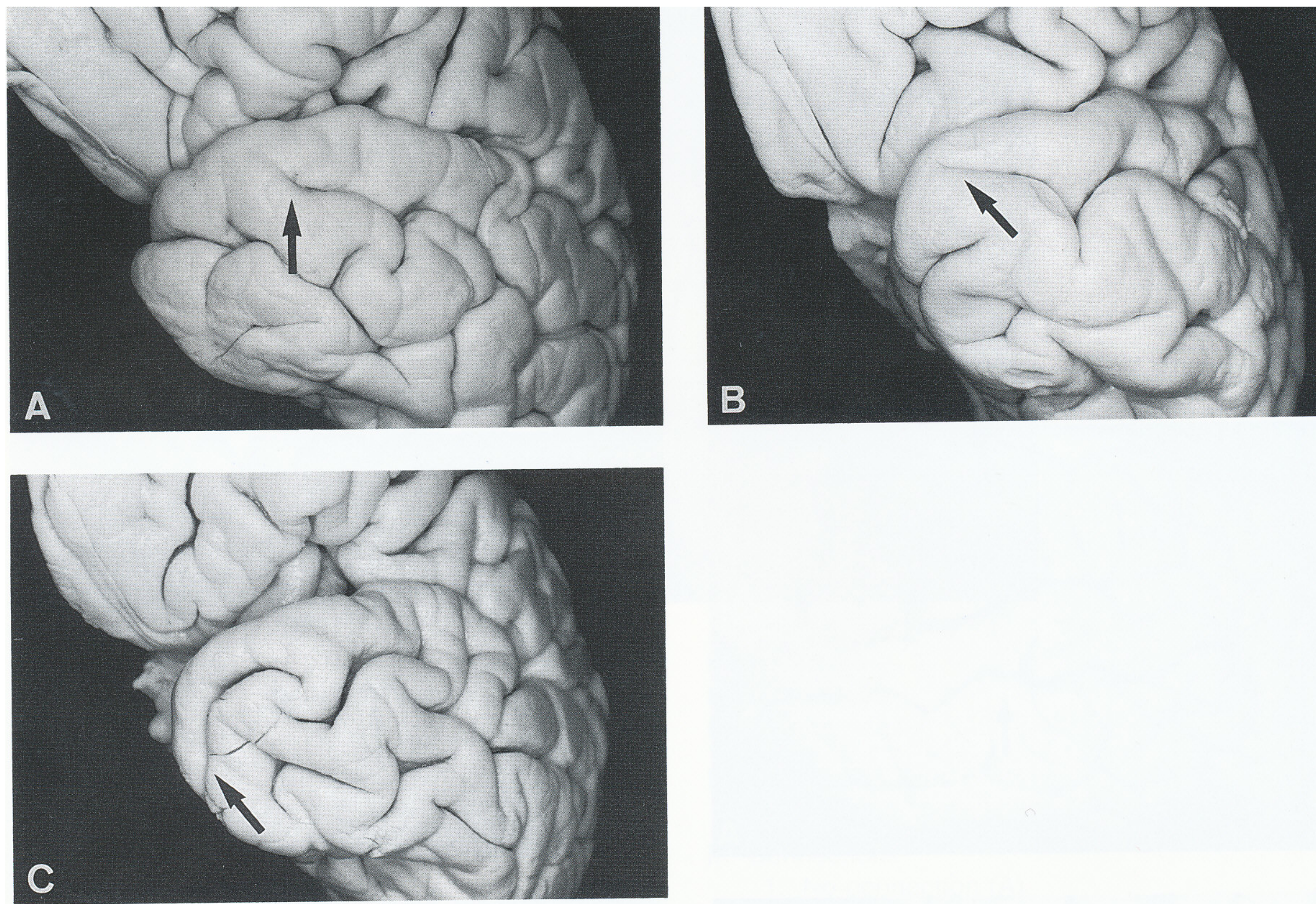
Variations of the superior temporal sulcus

A. Continuous
B. Interrupted 2 sgmts
C. Interrupted 3 sgmts
D. Interrupted 4 sgmts



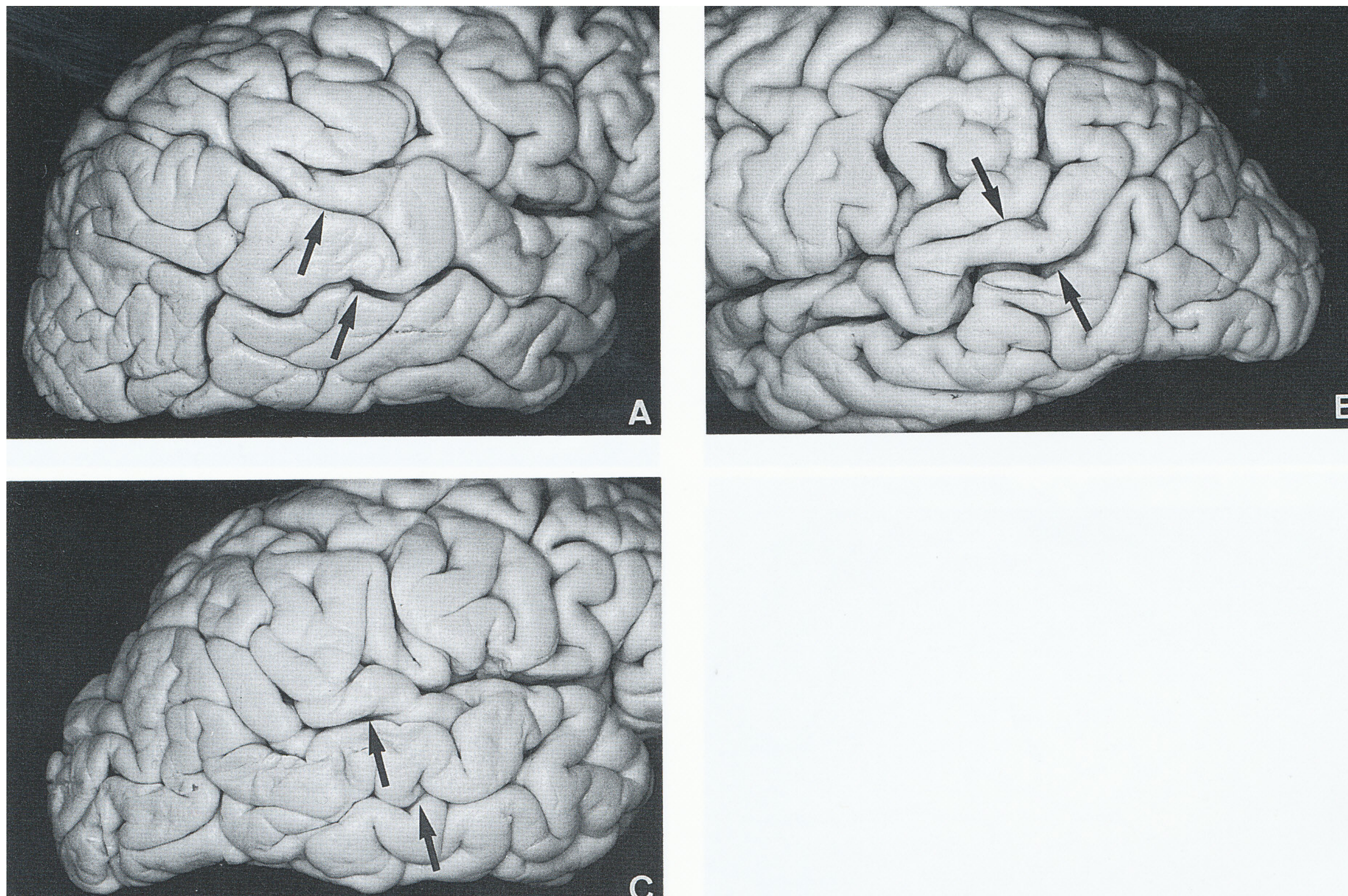
Morphological Anatomy

Variations of the anterior end s. temporal sulcus



Morphological Anatomy

Variations
of the
posterior end
s. temporal
sulcus



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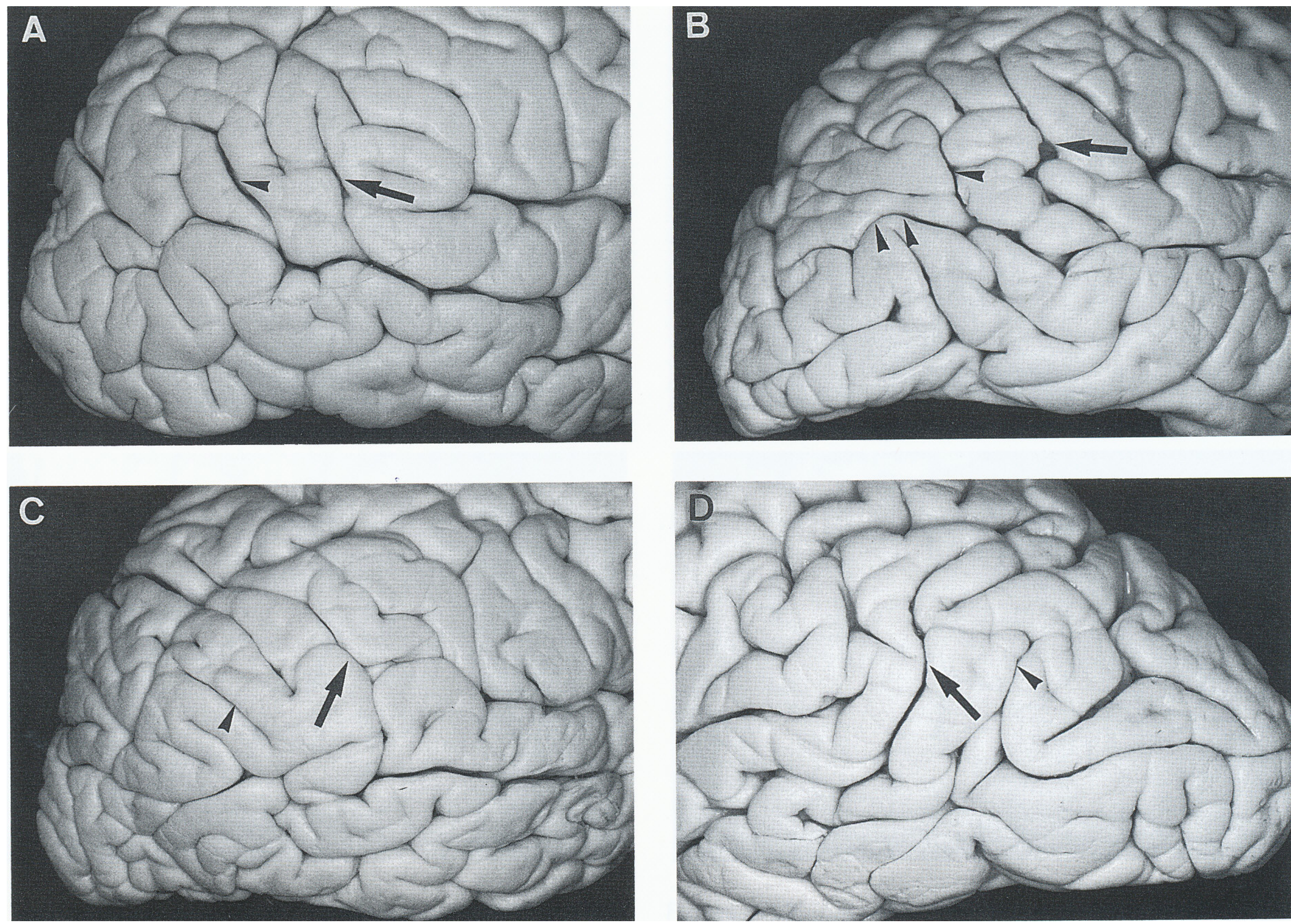
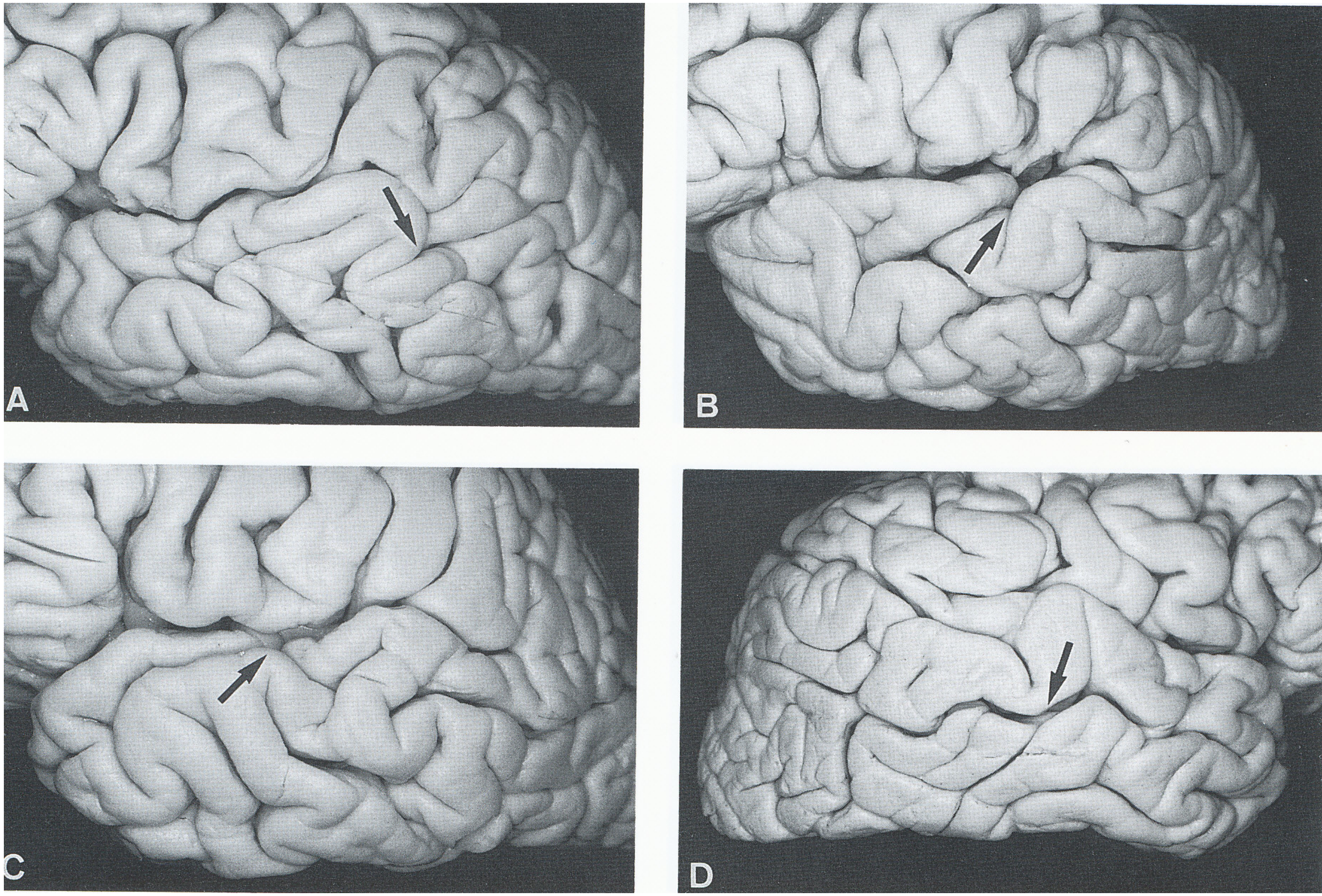
Morphological Anatomy



Variations of the posterior end s. temporal sulcus

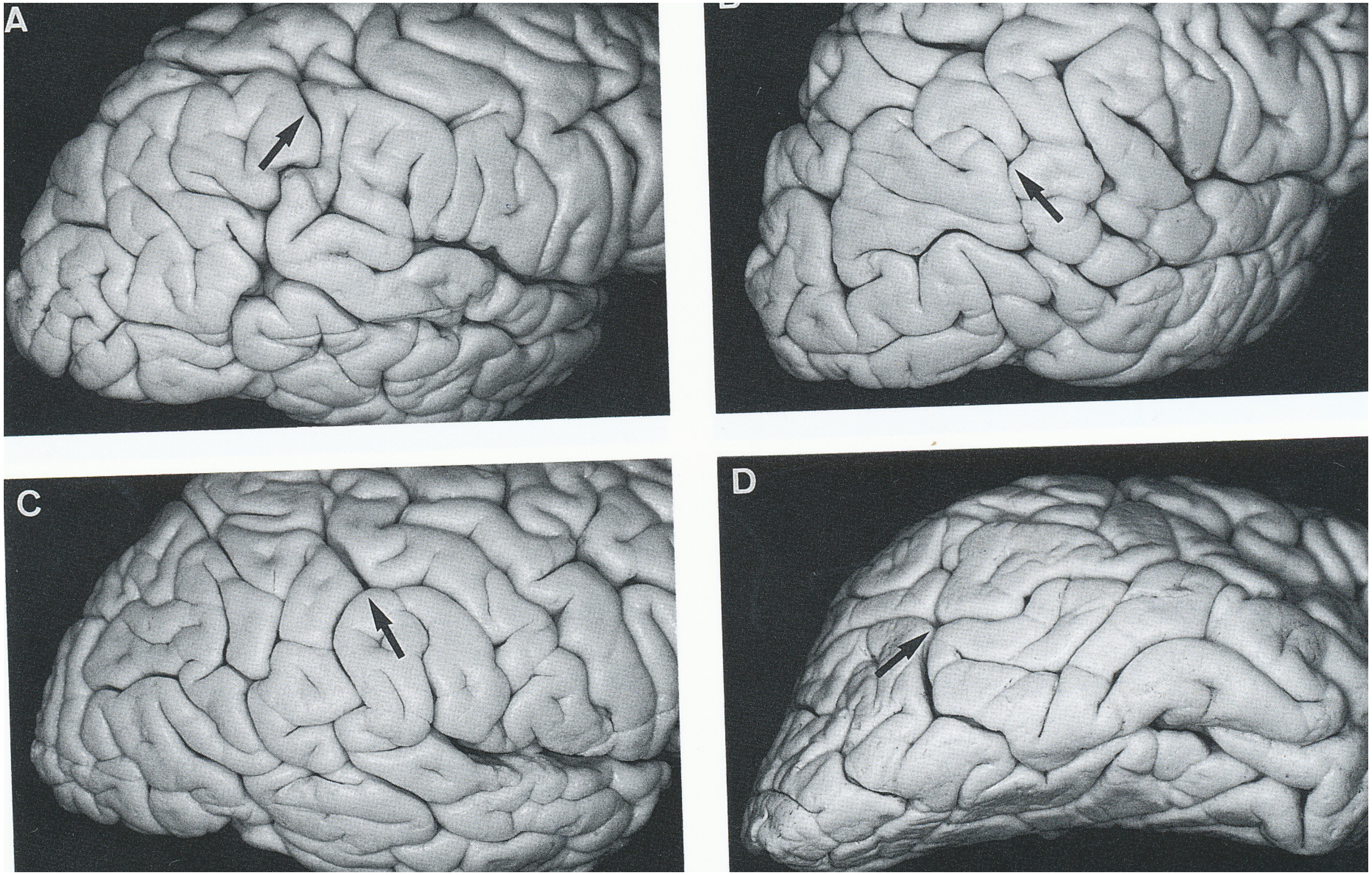
Morphological Anatomy

Variations of the connections s. temporal sulcus



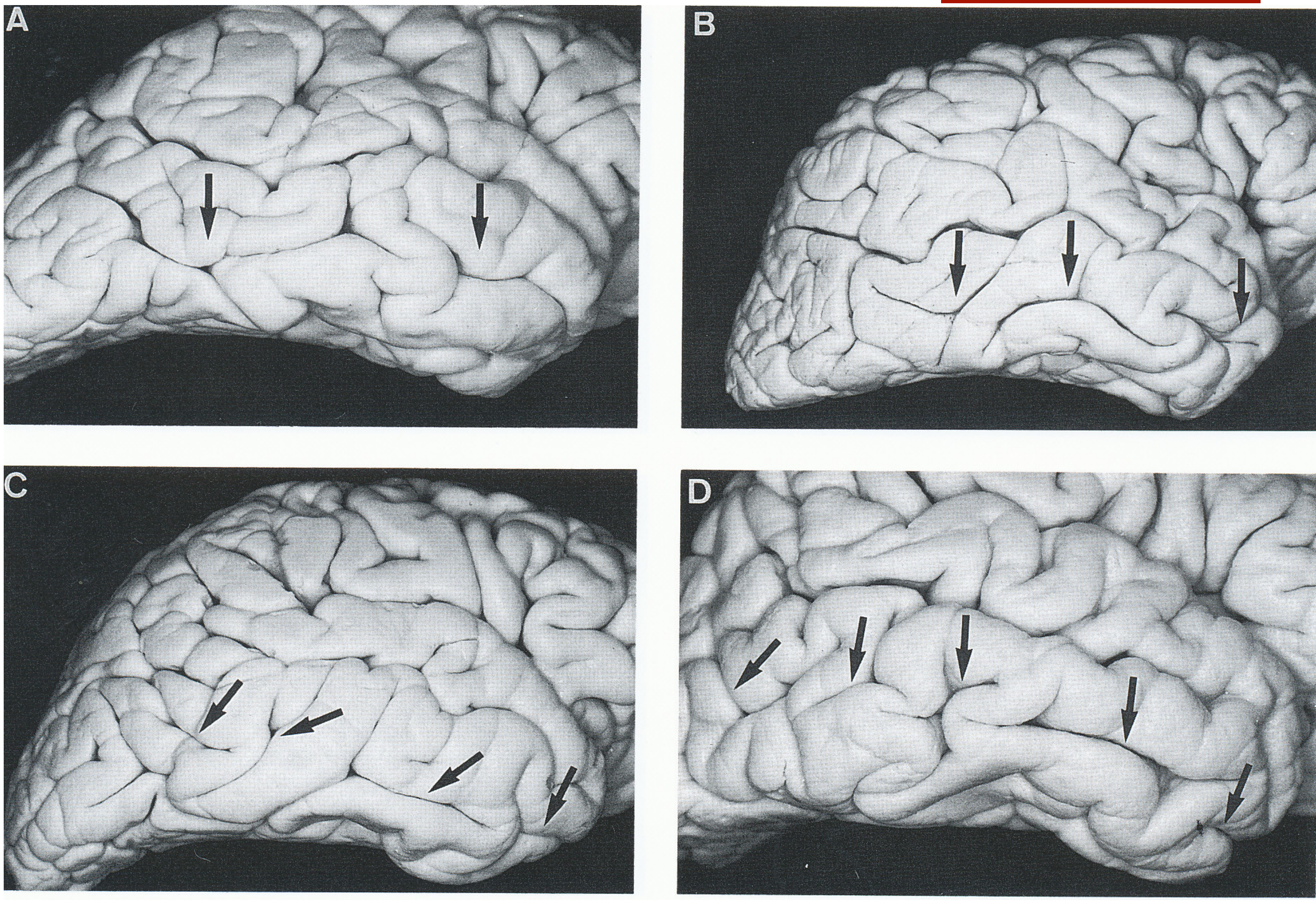
Morphological Anatomy

Variations of the connections s. temporal sulcus



Morphological Anatomy

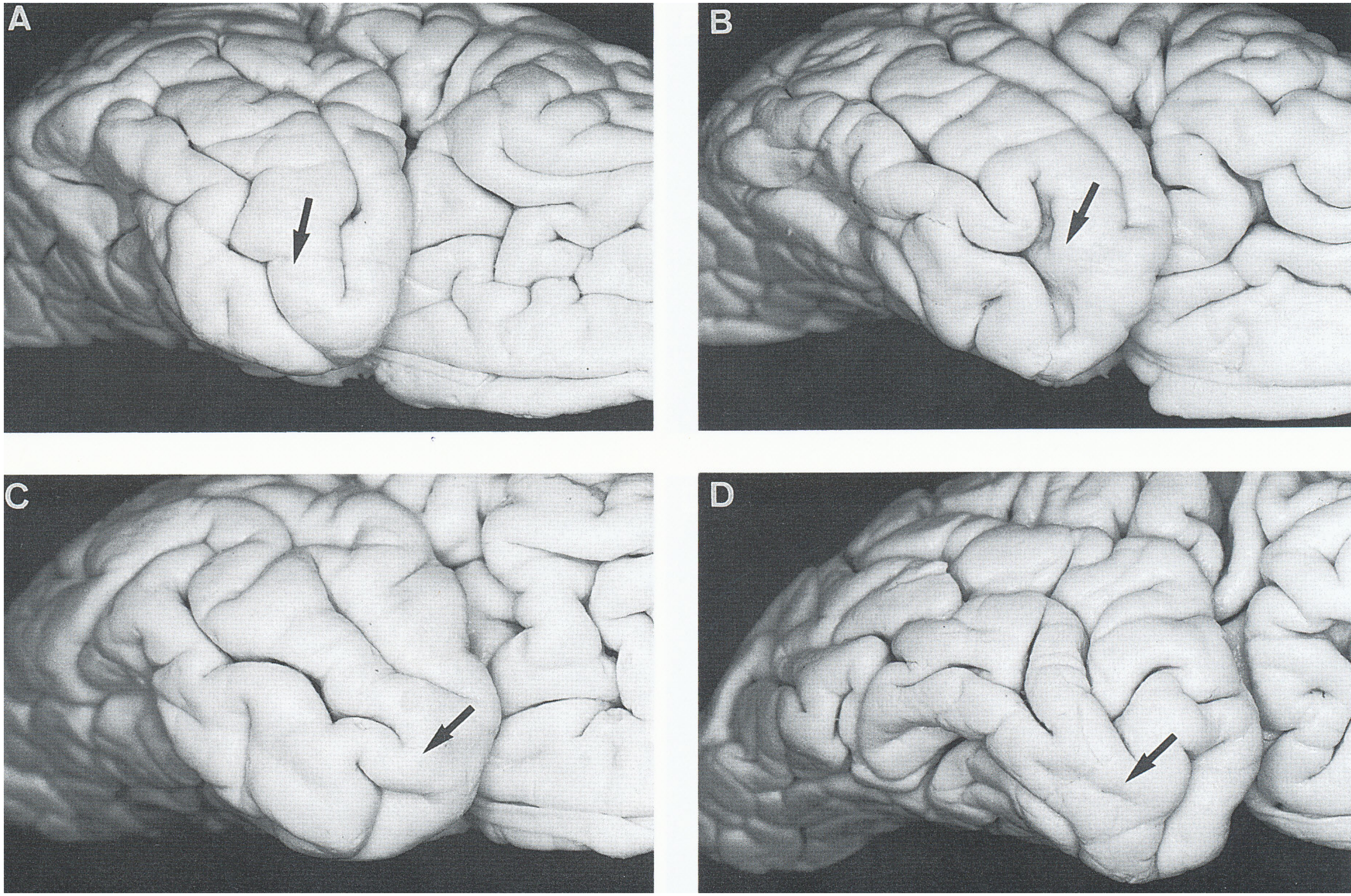
Variations of the inferior temporal sulcus



A. Interrupted 2 sgmts
B. Interrupted 3 sgmts
C. Interrupted 4 sgmts
D. Interrupted 5 sgmts
E. Interrupted 6 sgmts

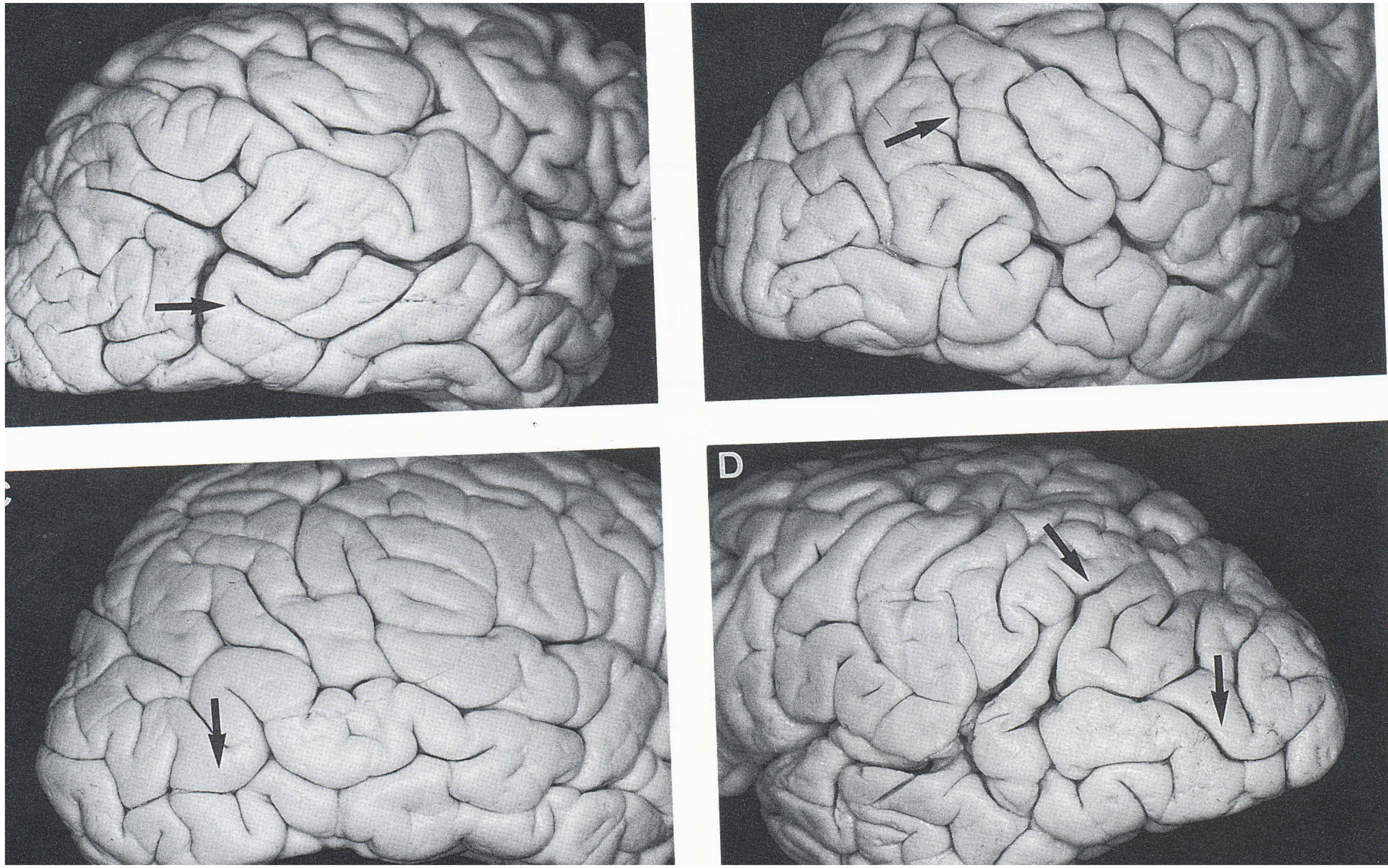
Morphological Anatomy

Variations of the anterior end inf. temporal sulcus



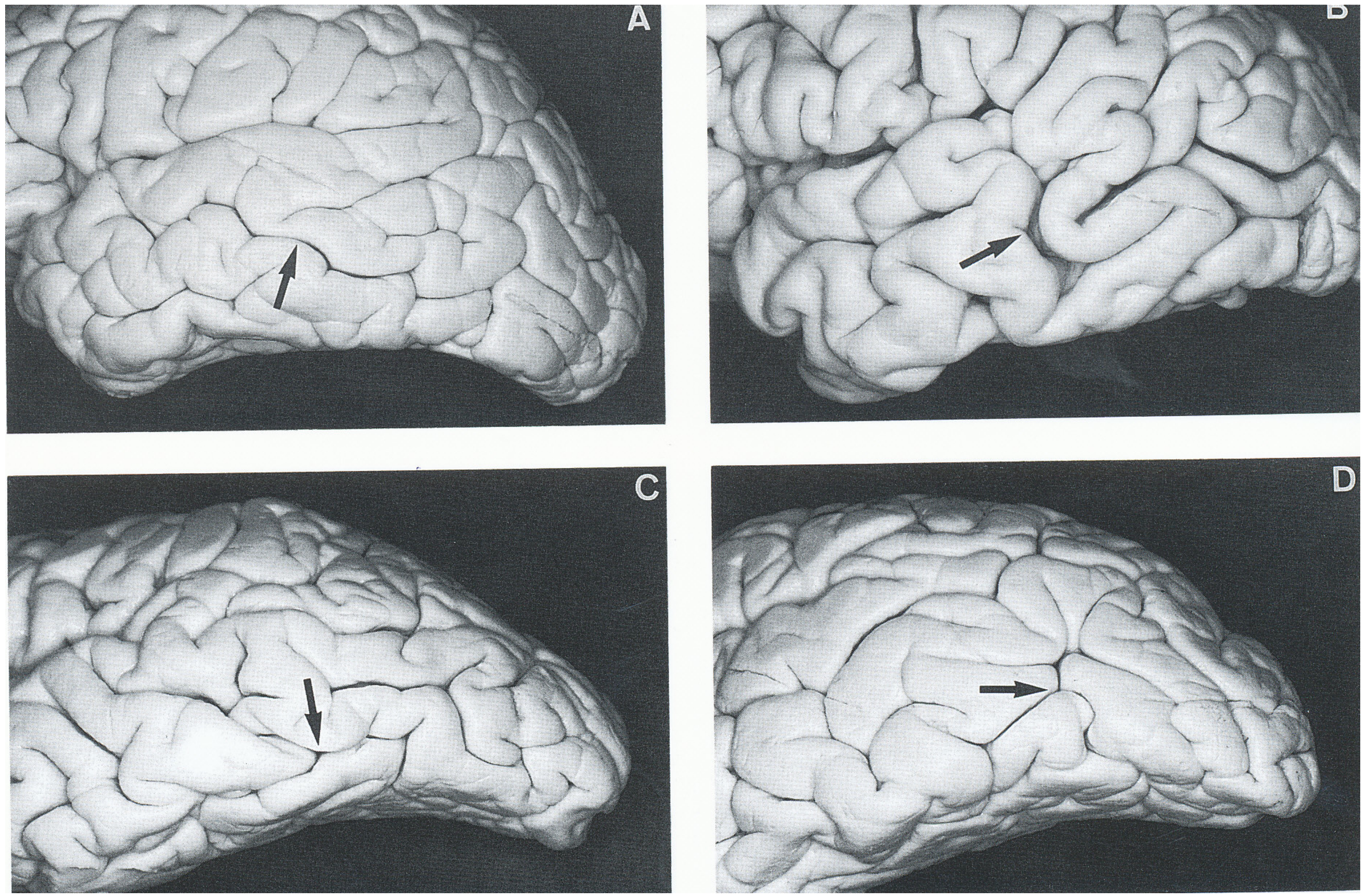
Morphological Anatomy

Variations
of the
posterior end
inf. temporal
sulcus



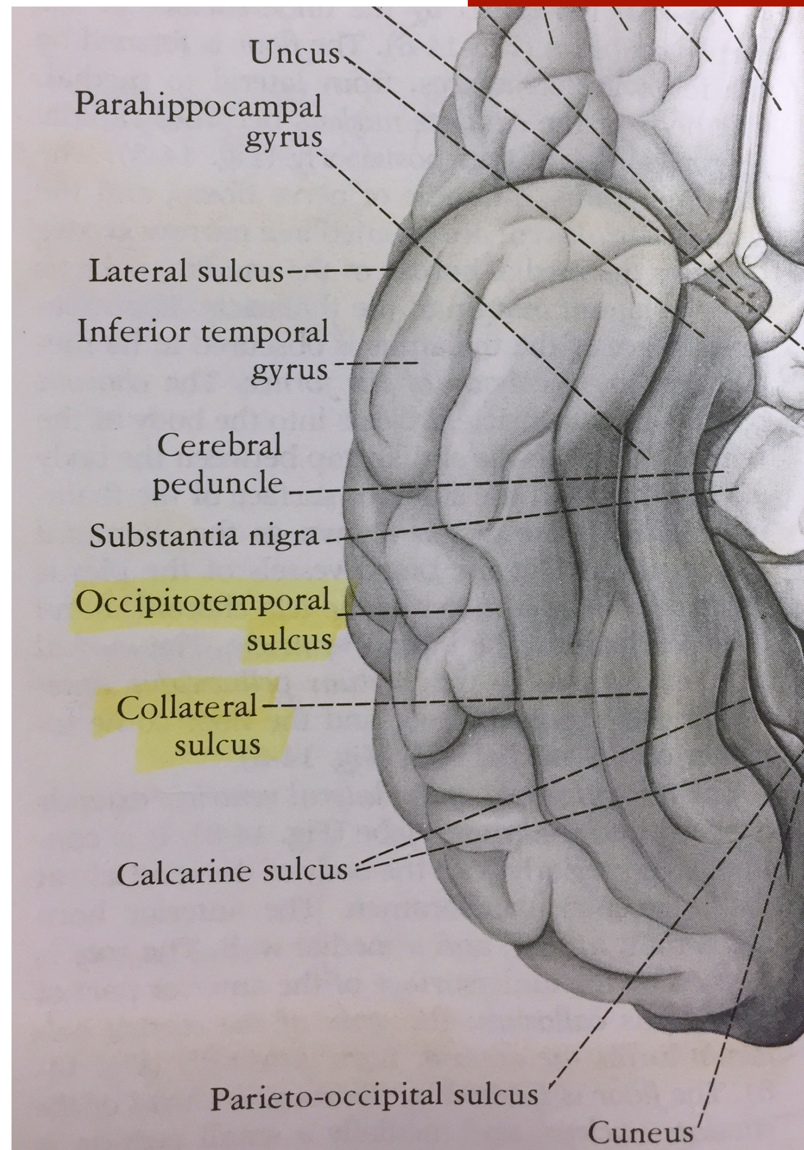
Morphological Anatomy

Variations of the connections s. temporal sulcus



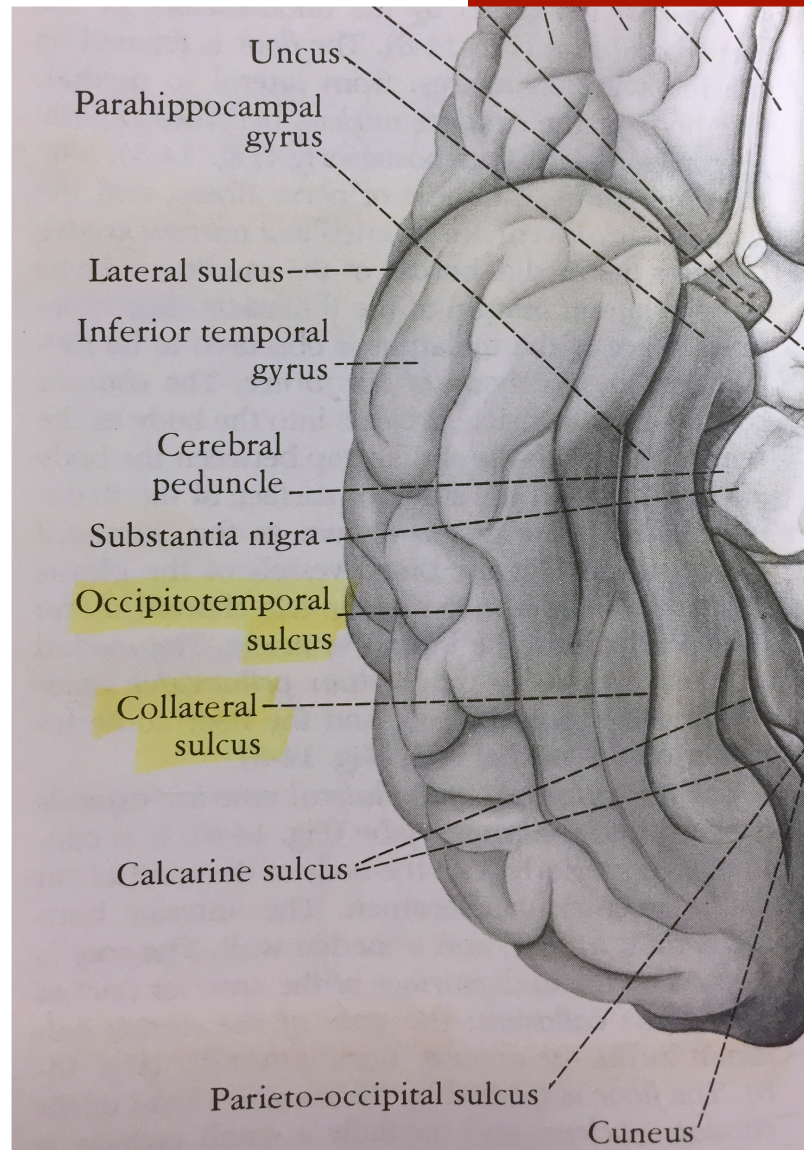
Morphological Anatomy

- Collateral sulcus runs on the inferior surface, and runs anteriorly to the calcarine sulcus. Thus, the lingual gyrus (between the calcarine and collateral sulci), and the parahippocampal gyri are defined. The uncus is anteriorly to the parahippocampal gyrus.



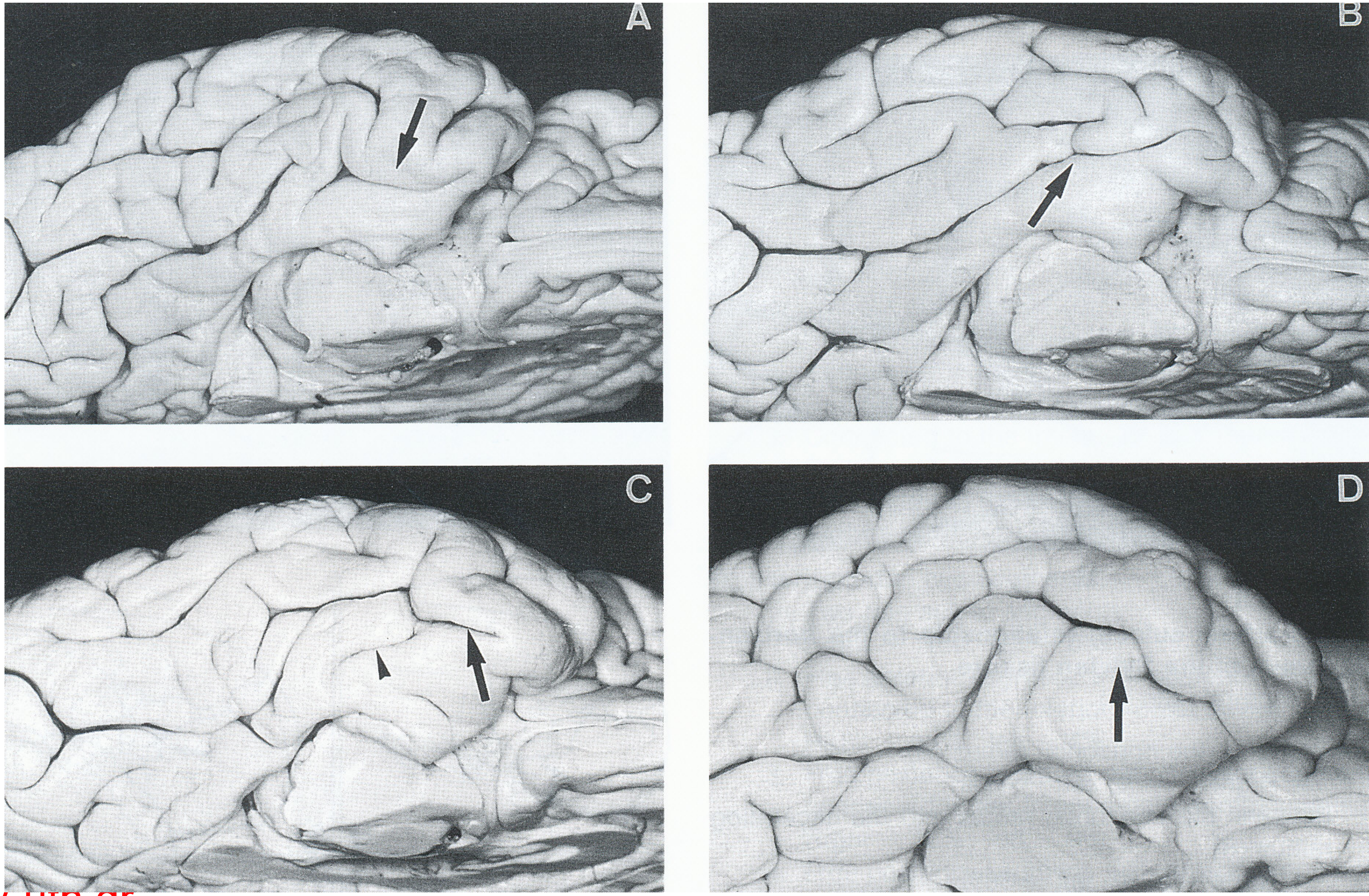
Morphological Anatomy

- The medial occipitotemporal gyrus extends from the occipital to the temporal pole. It is bounded medially by the collateral and rhinal sulci, and laterally by the occipitotemporal sulcus.



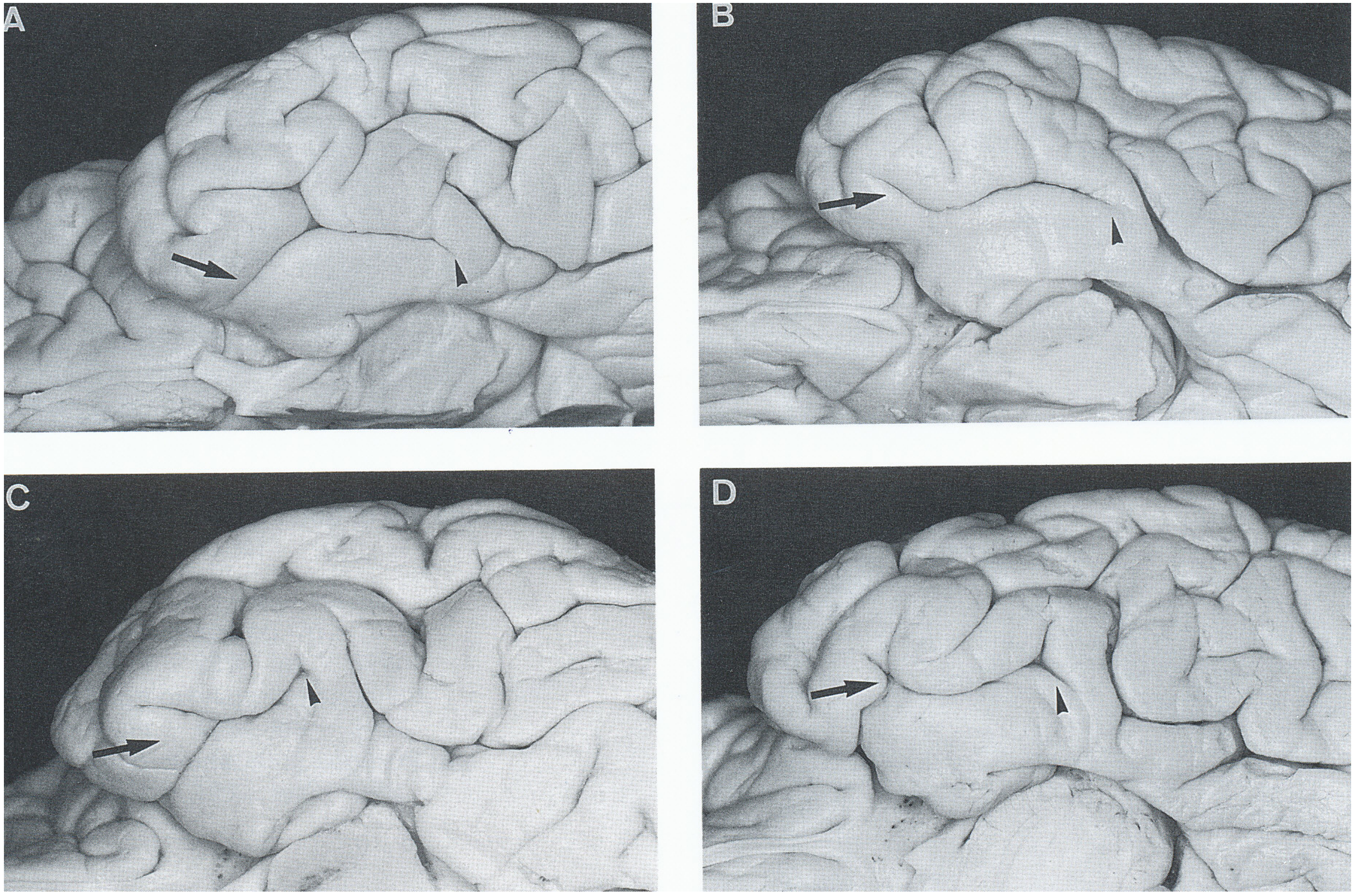
Morphological Anatomy

Variations of the rhinal sulcus



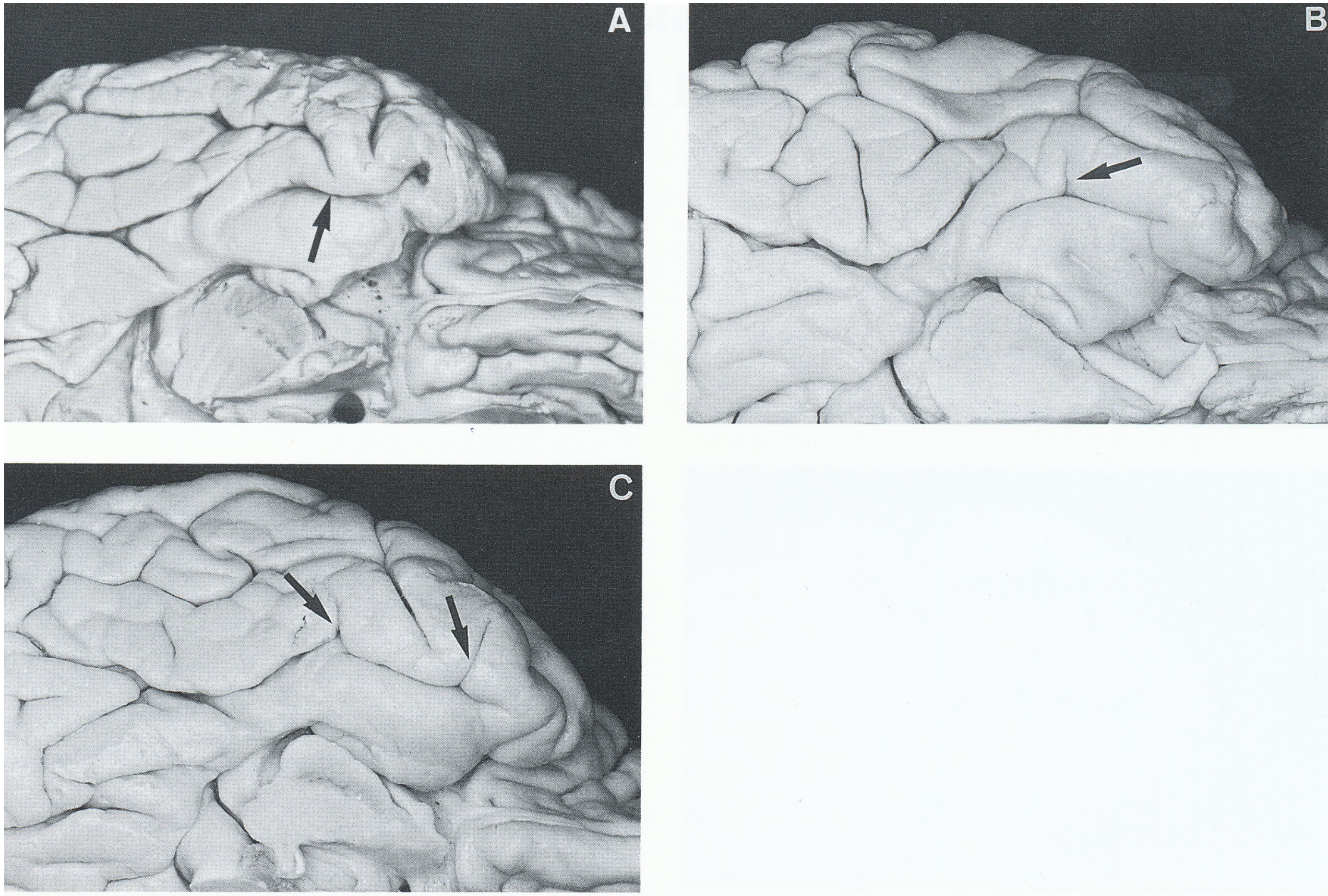
Morphological Anatomy

Variations of the rhinal sulcus anterior & posterior ends



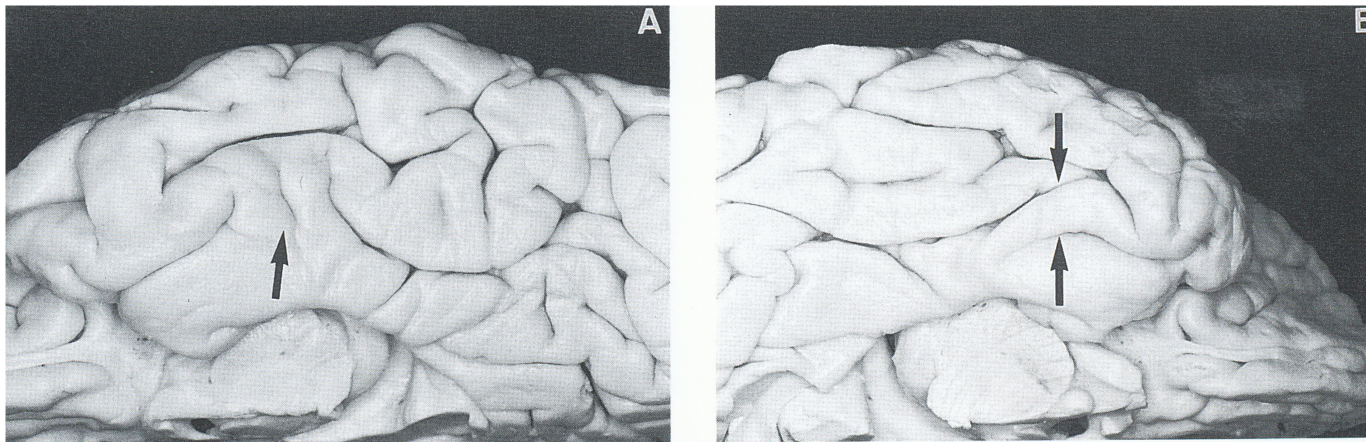
Morphological Anatomy

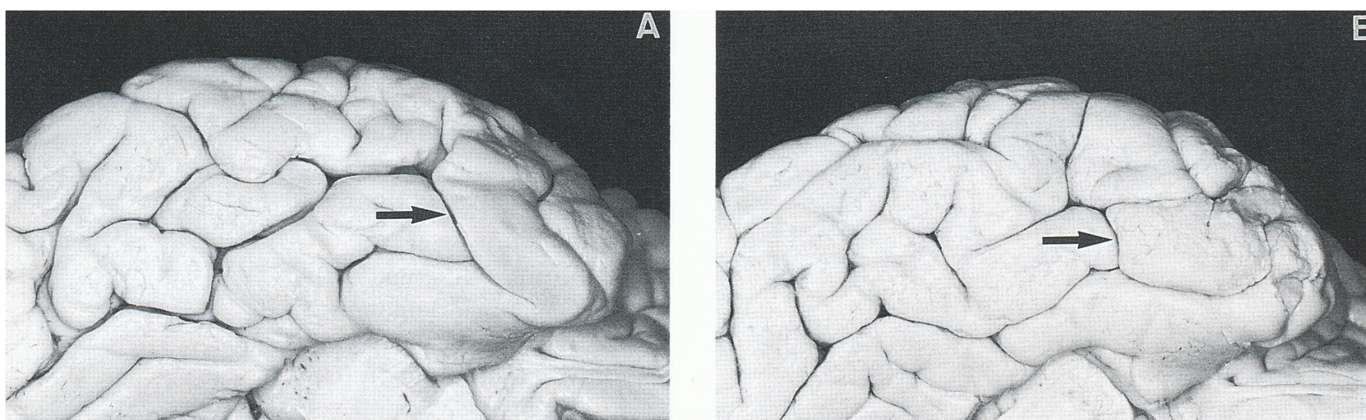
Variations of the rhinal sulcus side branches



Morphological Anatomy

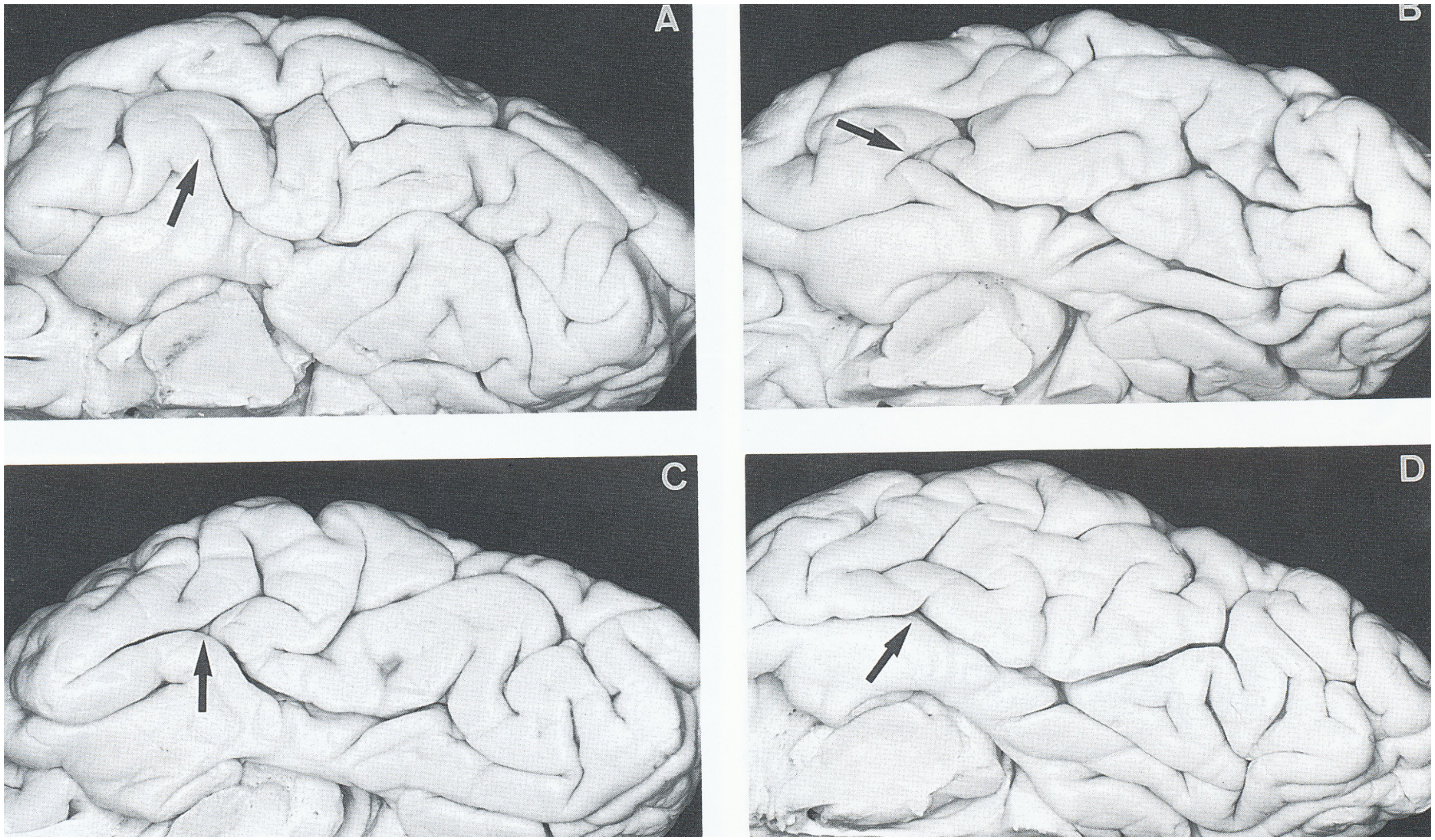
Variations of the rhinal sulcus connections





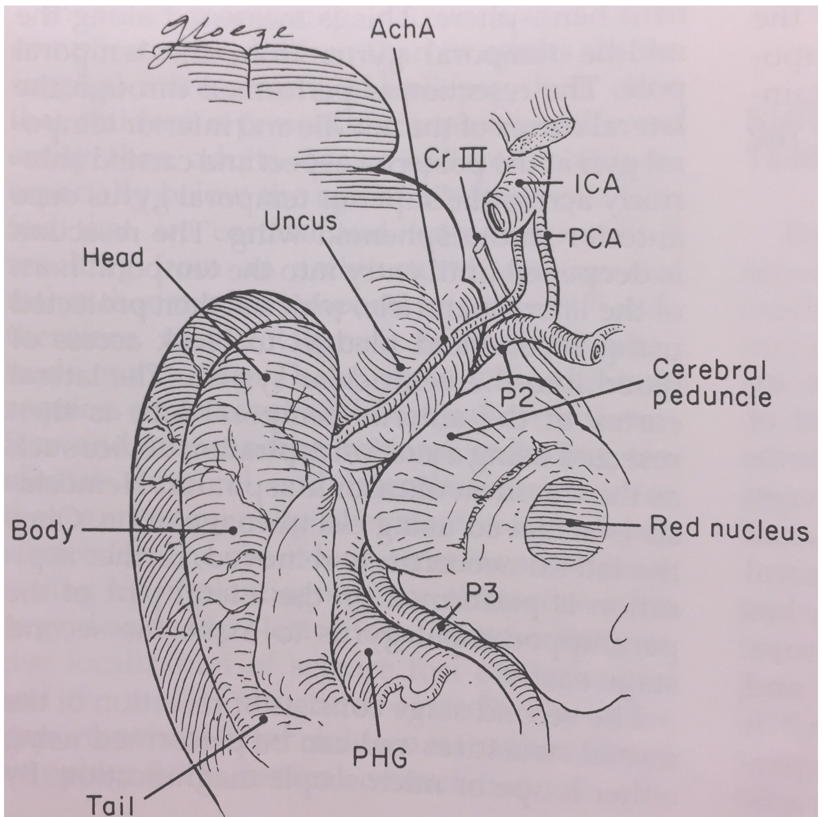
Morphological Anatomy

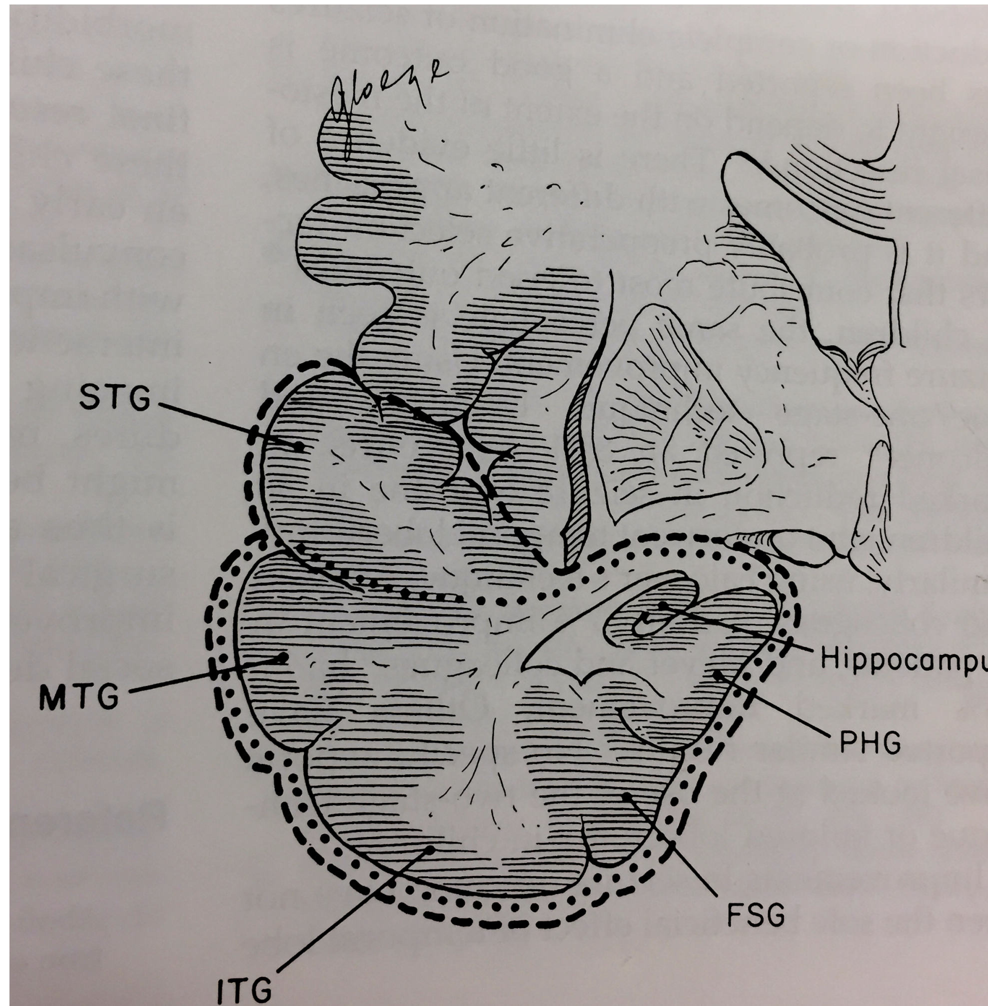
Variations of the collateral sulcus



Morphological Anatomy

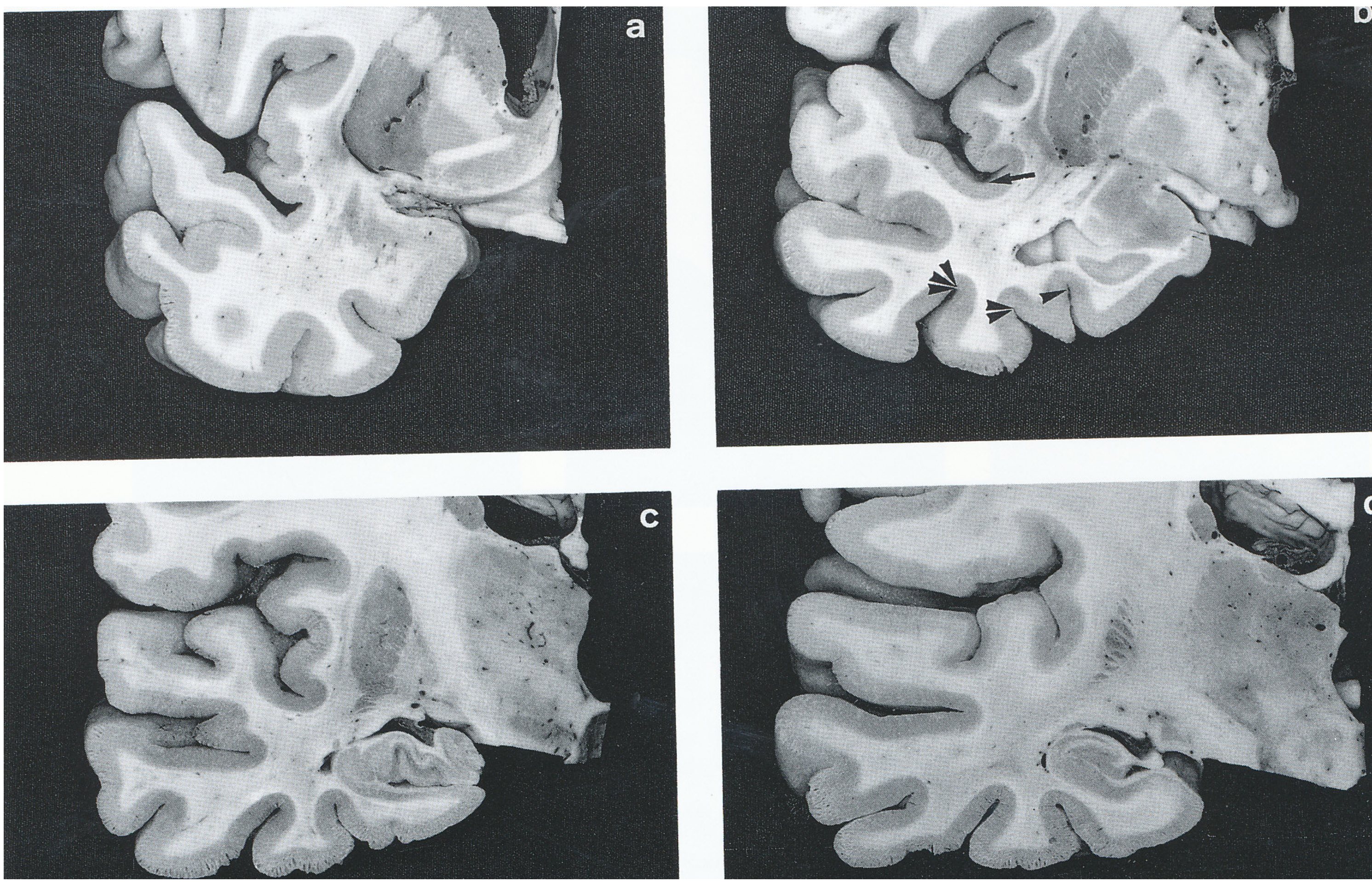
- The inferior surface on a coronal view





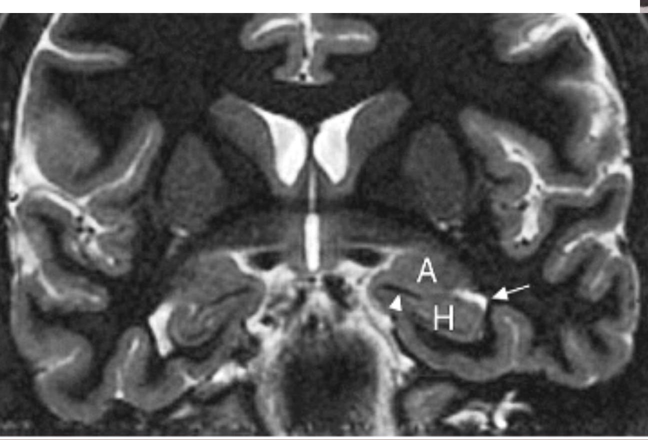
Morphological Anatomy

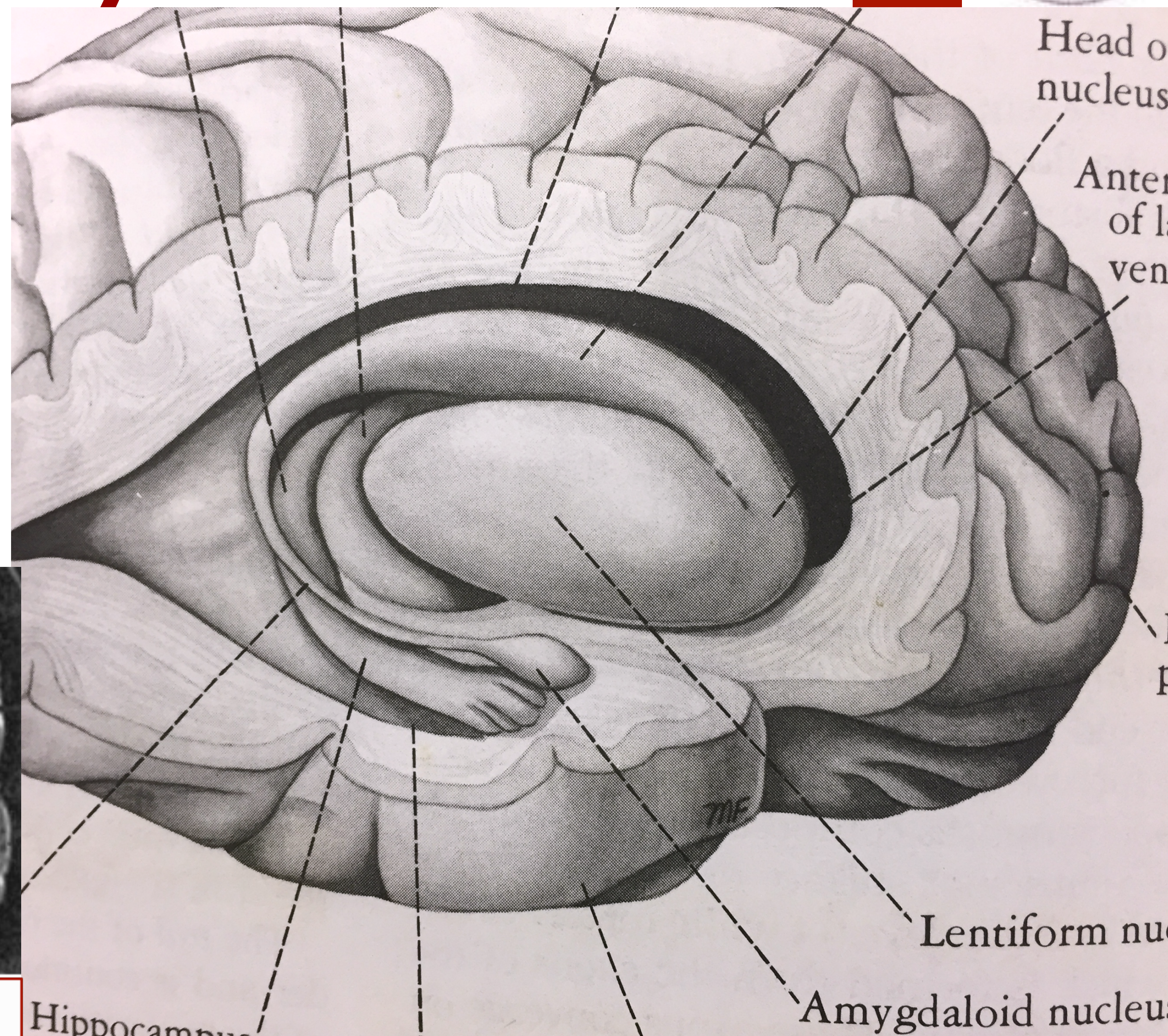
Coronal section



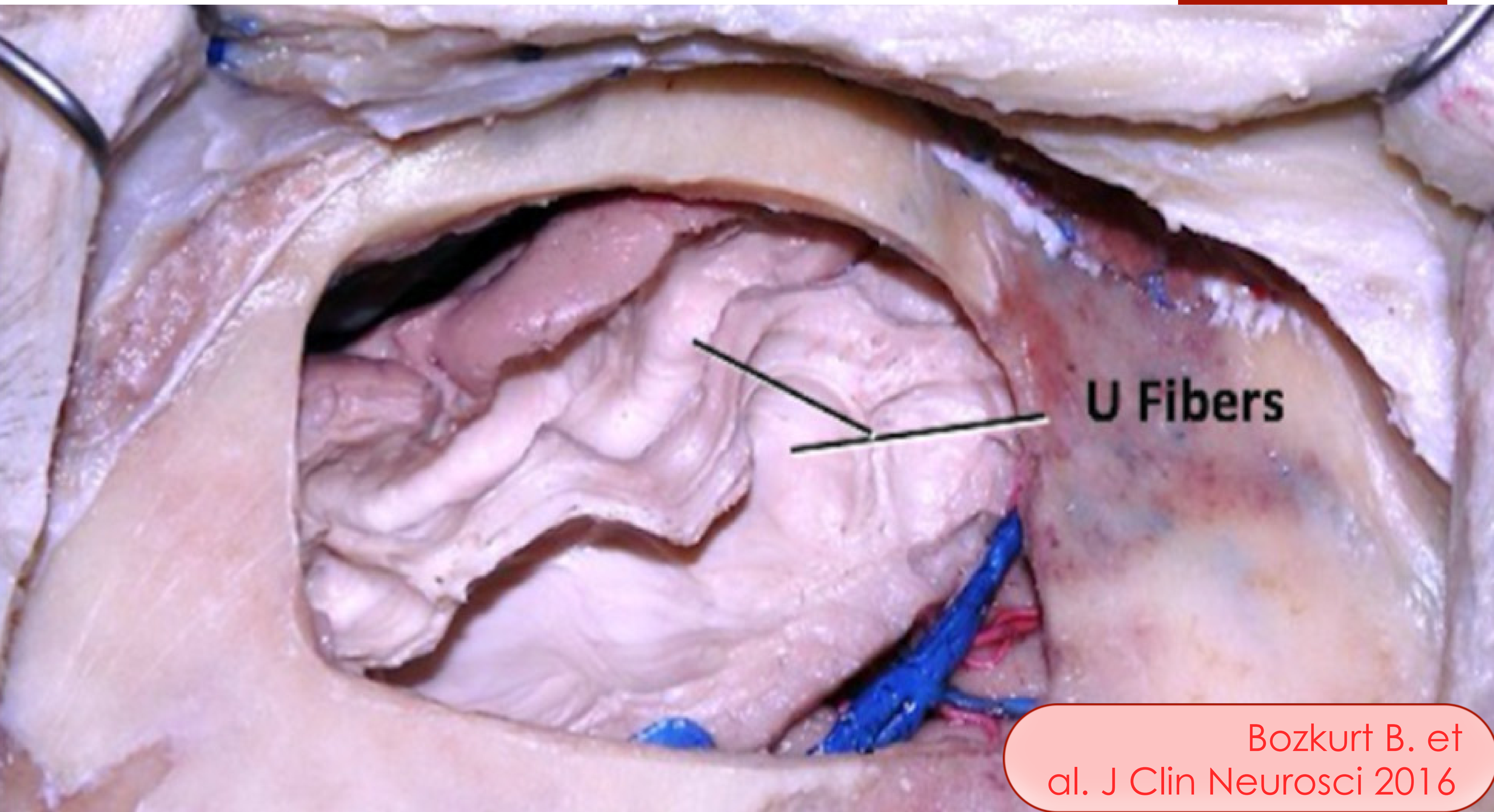
Morphological Anatomy

- The amygdaloid nucleus and its topographical anatomy



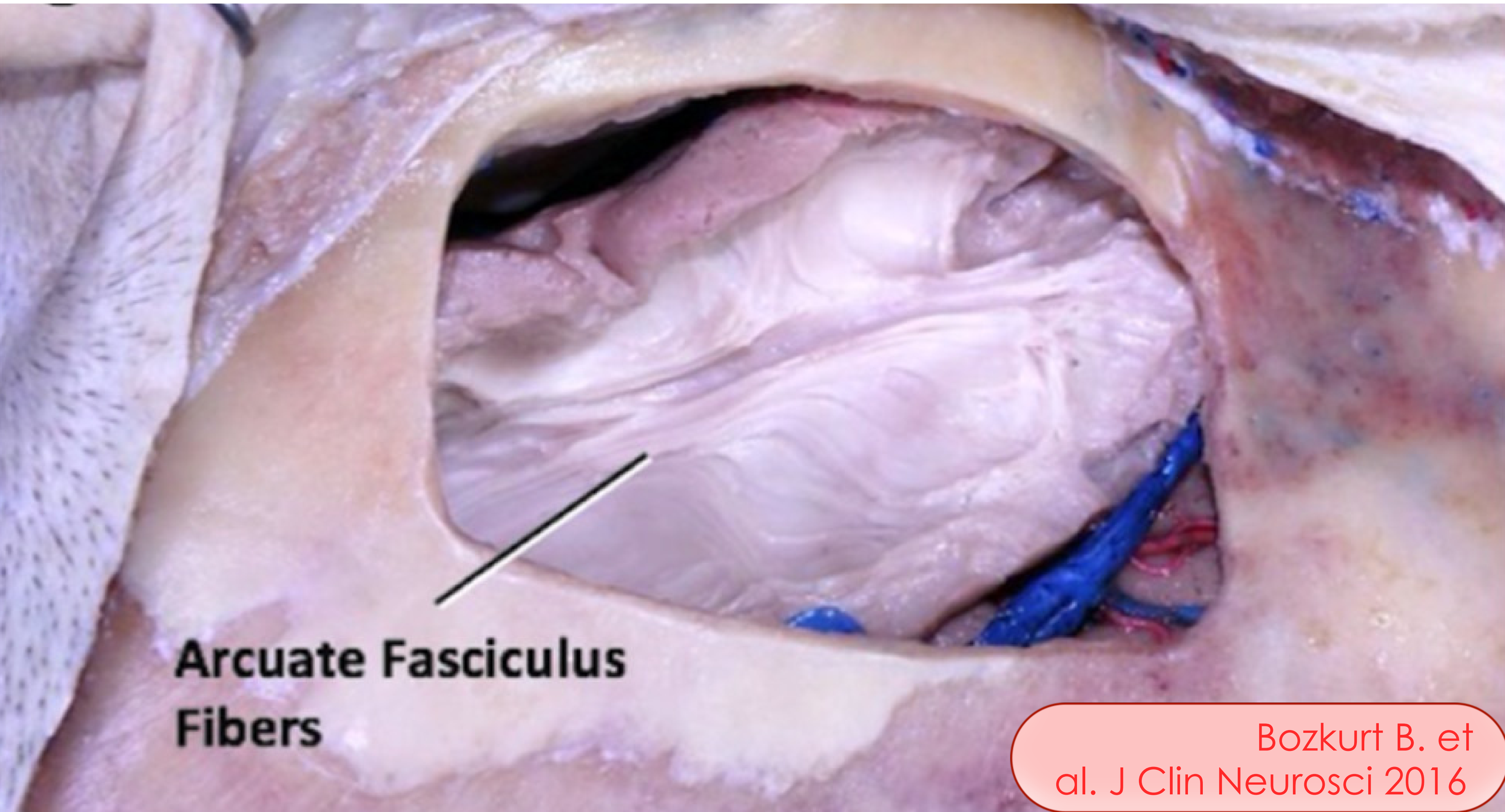


White Matter Tracts (I)



Bozkurt B. et al. J Clin Neurosci 2016

White Matter Tracts (II)



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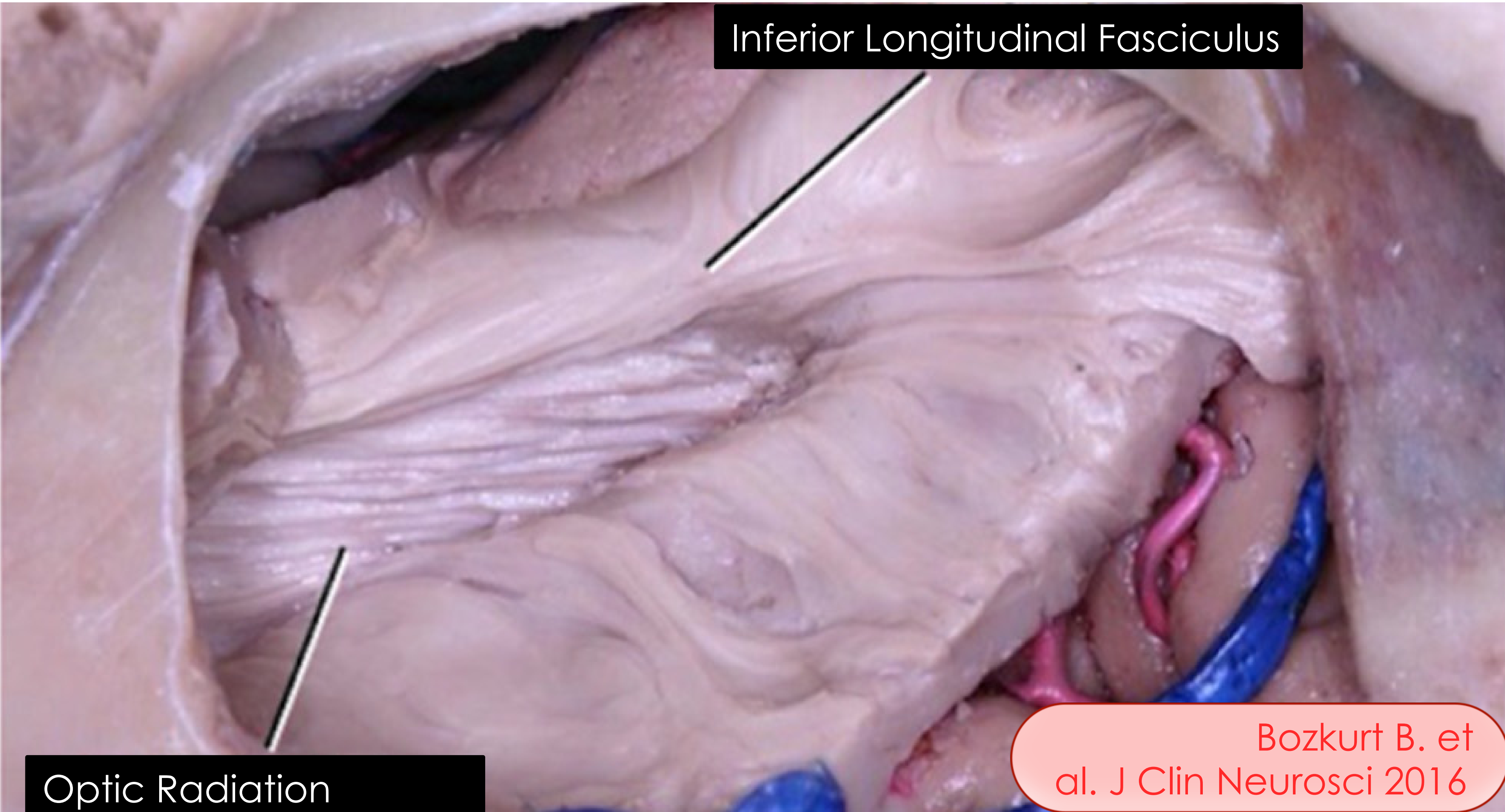
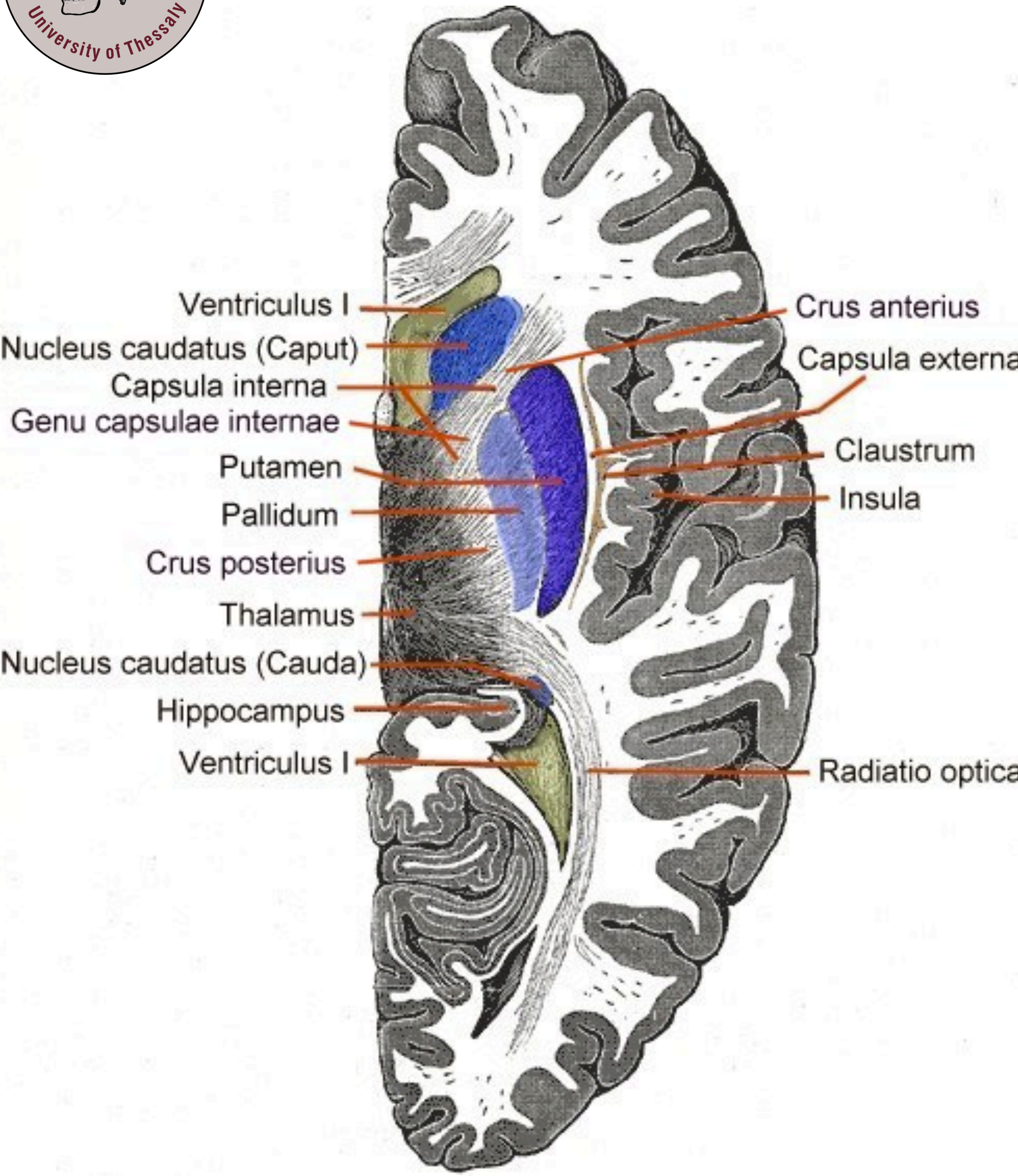
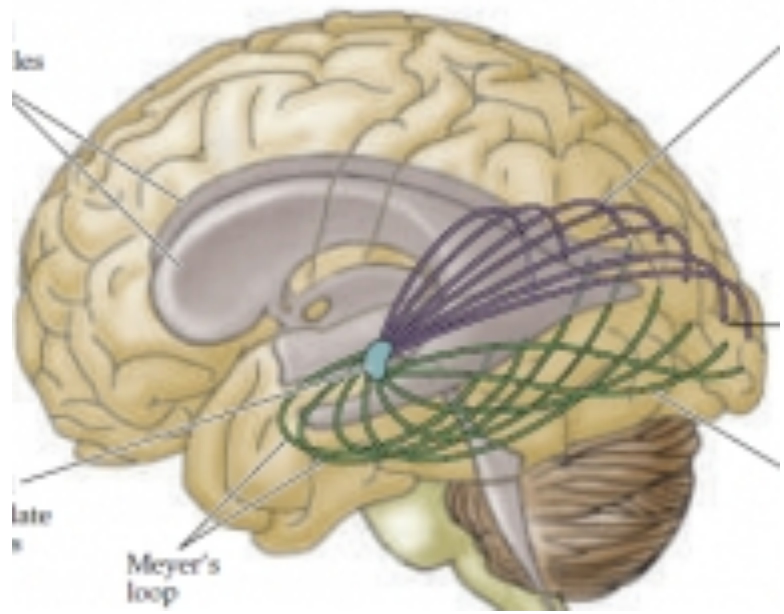
White Matter Tracts (III)



Visual Pathway



Anatomical variation?
Displacement?



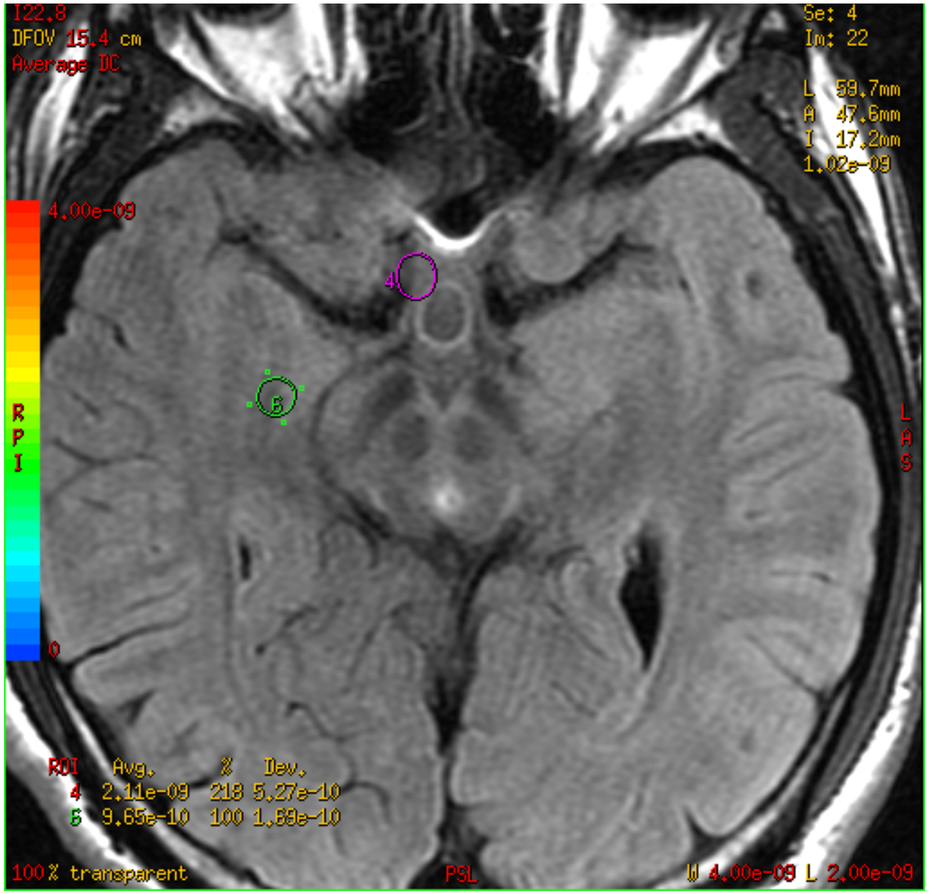
Methods: DTI

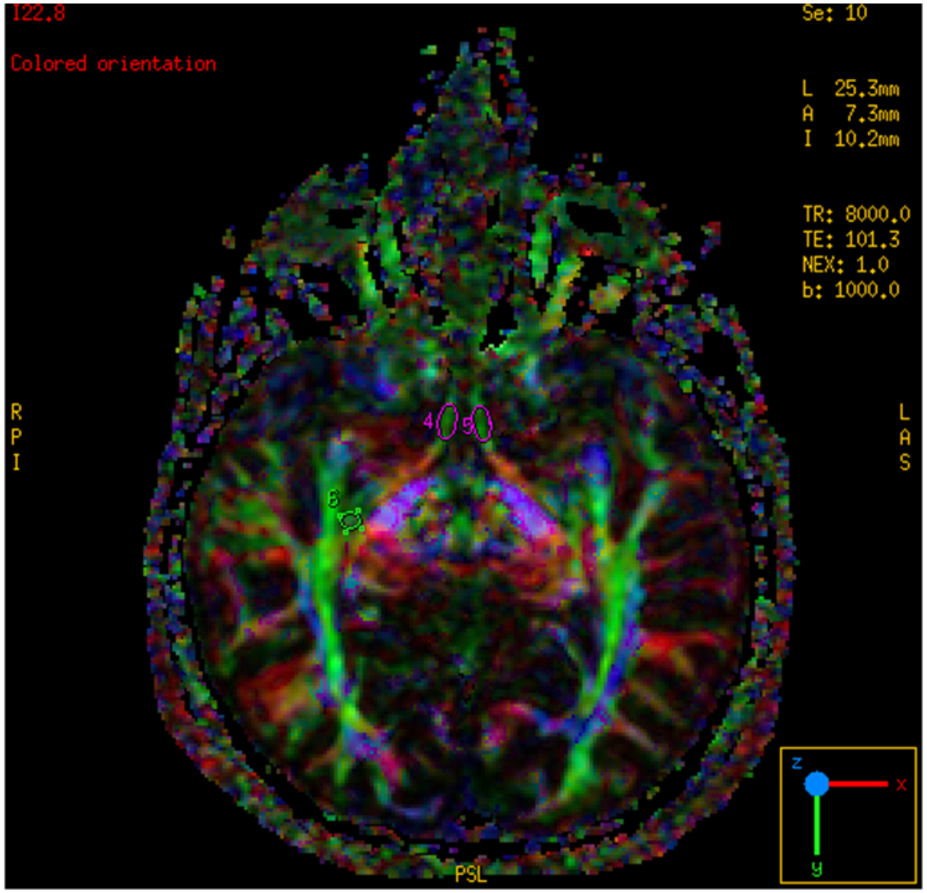
- The DTI images are obtained in the axial plane, with slice thickness of 3mm (no interslice gap) and 32 directions. Total acquisition time is approximately 5 min.

- The post processing is more complicated, and takes about 15-30 minutes for the identification of the optic radiation.

Methods: DTI

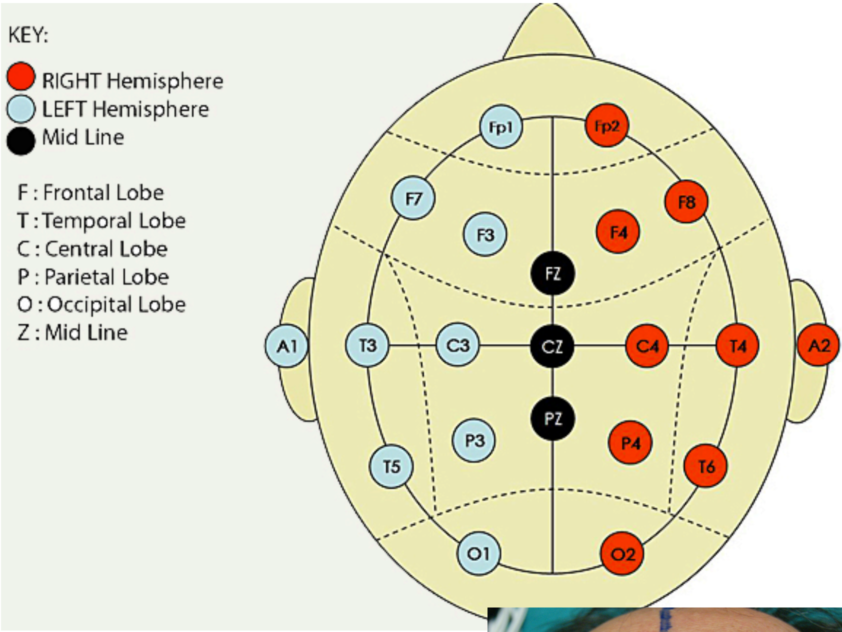
Axial T1 and axial color coded DTI image with ROIs





Methods: VEPs

- Visual Evoked Potential (VEP) monitoring has been used for assessing the functional integrity of the visual pathway during surgery



- **Standard bipolar montage**

  - positive electrode at O1/O2 site

  - negative electrode at A1/A2 site

  -ground electrode at the Fpz

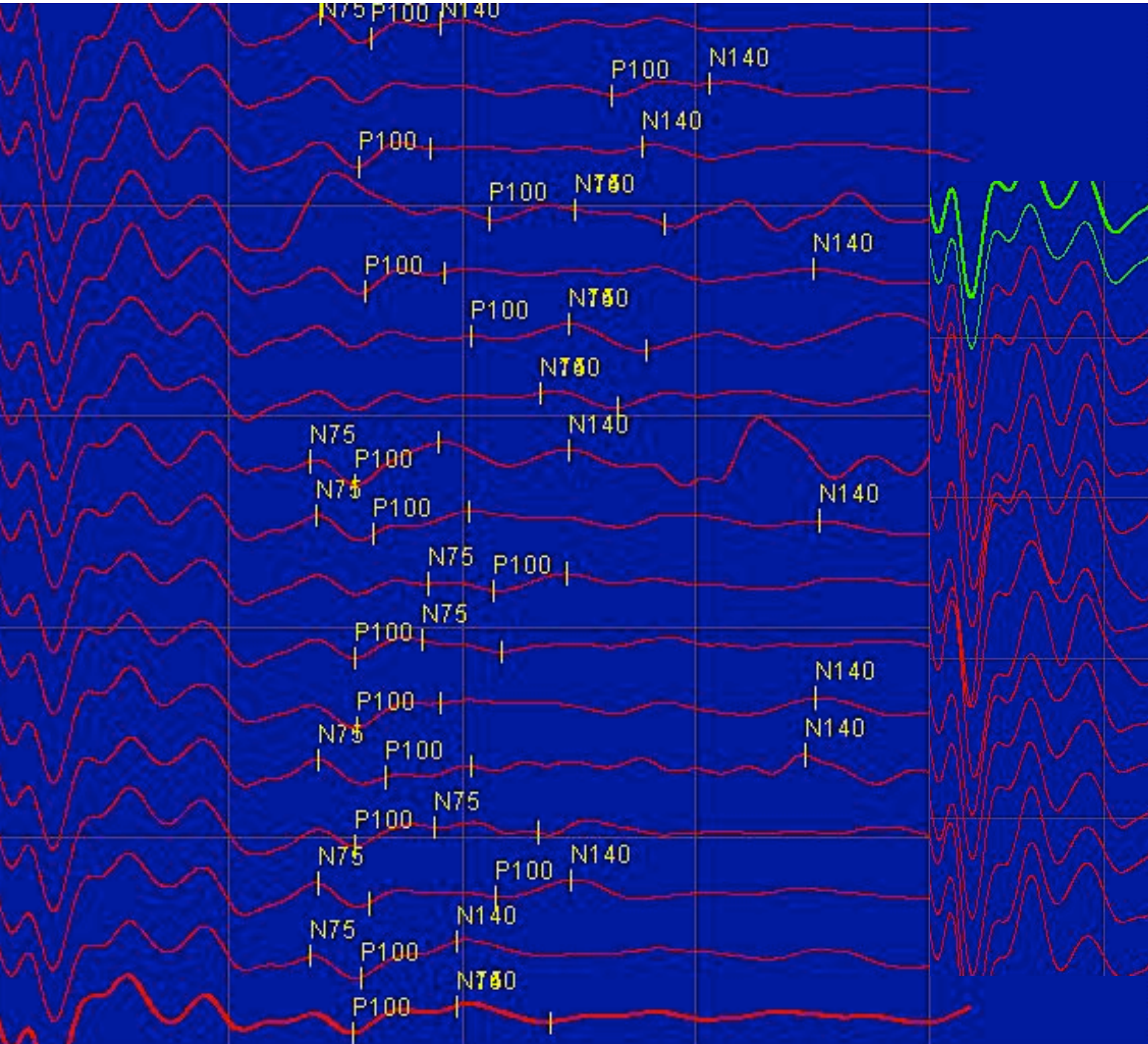
- **Stimulation parameters:**

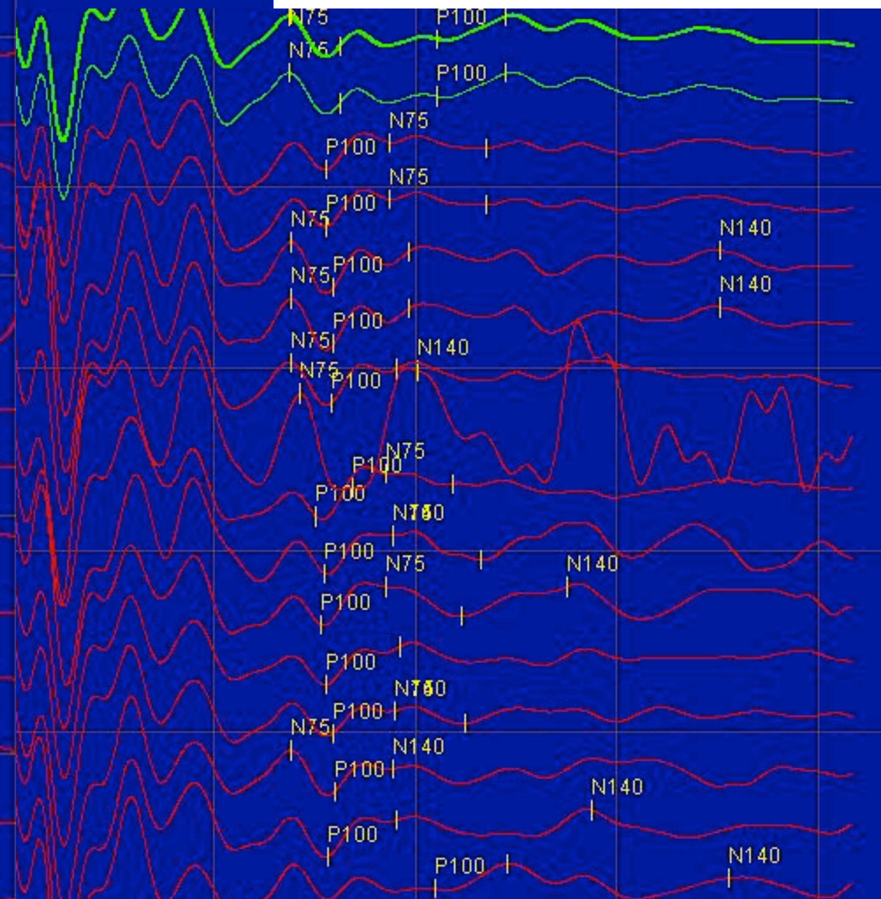
  - flash stimuli from red light-emitting diodes on goggles

  - stimulus duration : 5 msecs

  - frequency: 1-5 Hz

Methods: VEPs





Methods: VEPs

- Anesthesia interference:

  - hypothermia

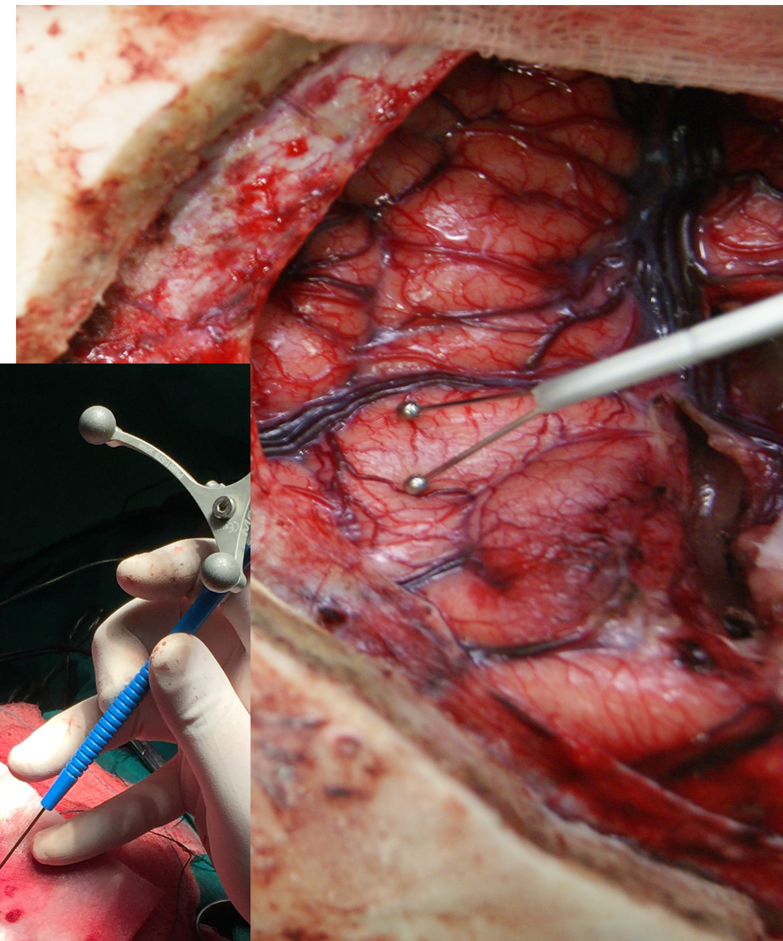
  - inhalation anesthetic agents

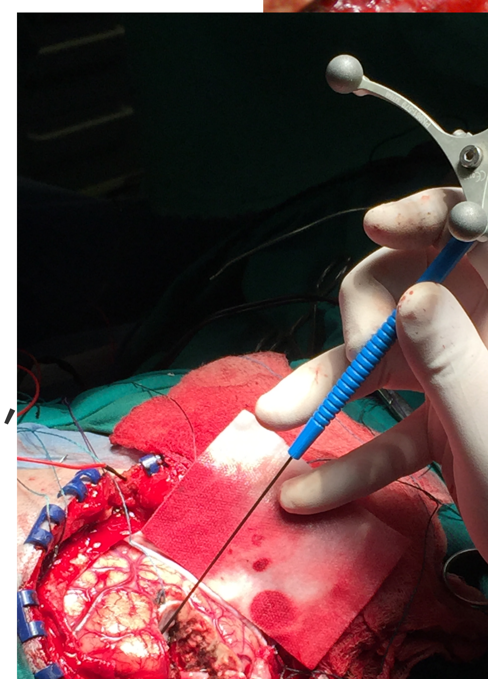
  - nitrous oxide

Increase latency &
Decrease peak amplitude

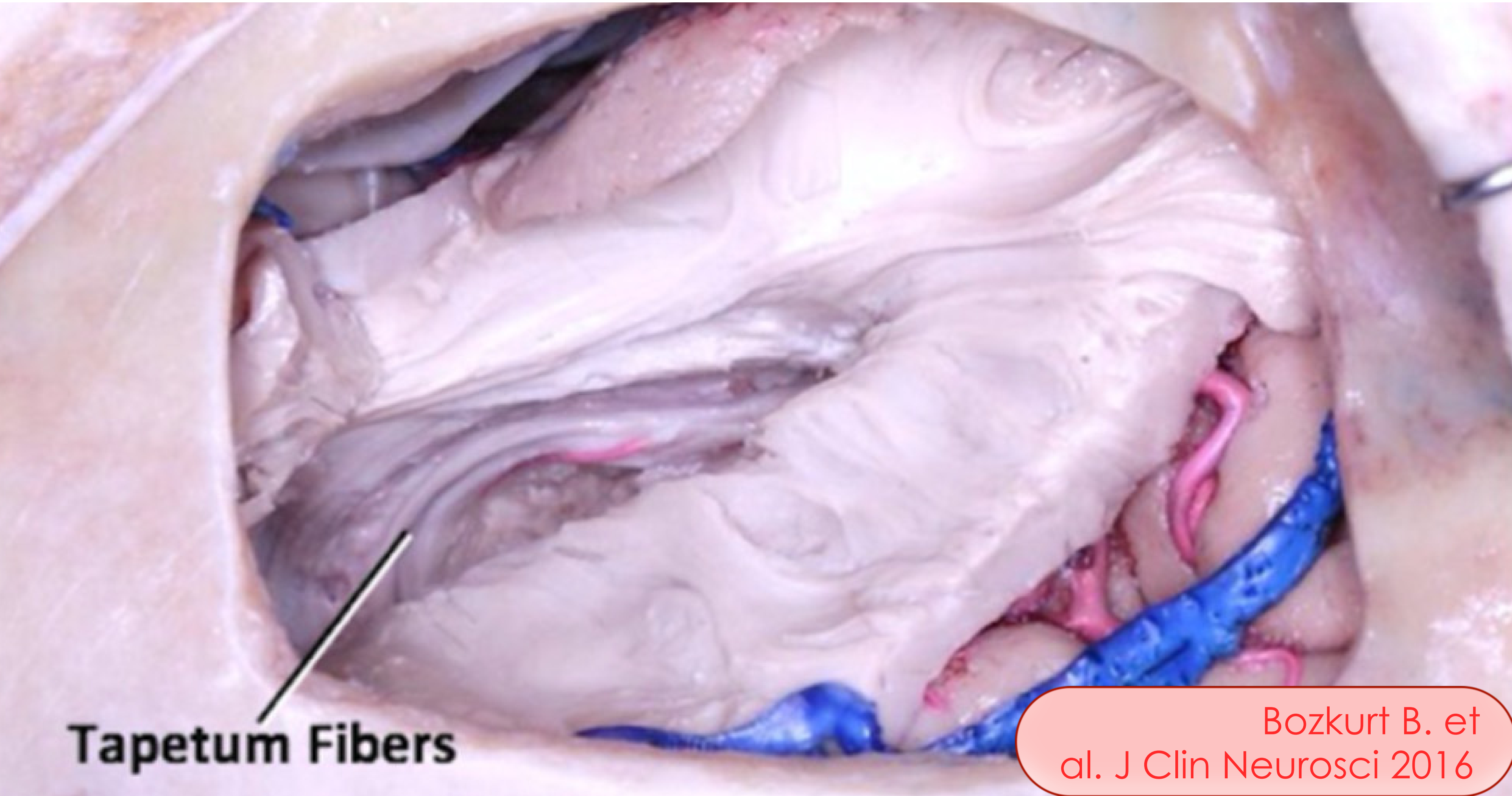
Methods: Direct Cortical & Subcortical Stimulation

- Bipolar & unipolar stimulation
- Stimulation parameters: Grass 88 stimulator, 50Hz, 3secs train, 0.2 ms alternating polarity, square-wave pulses, 4-14 mAmps





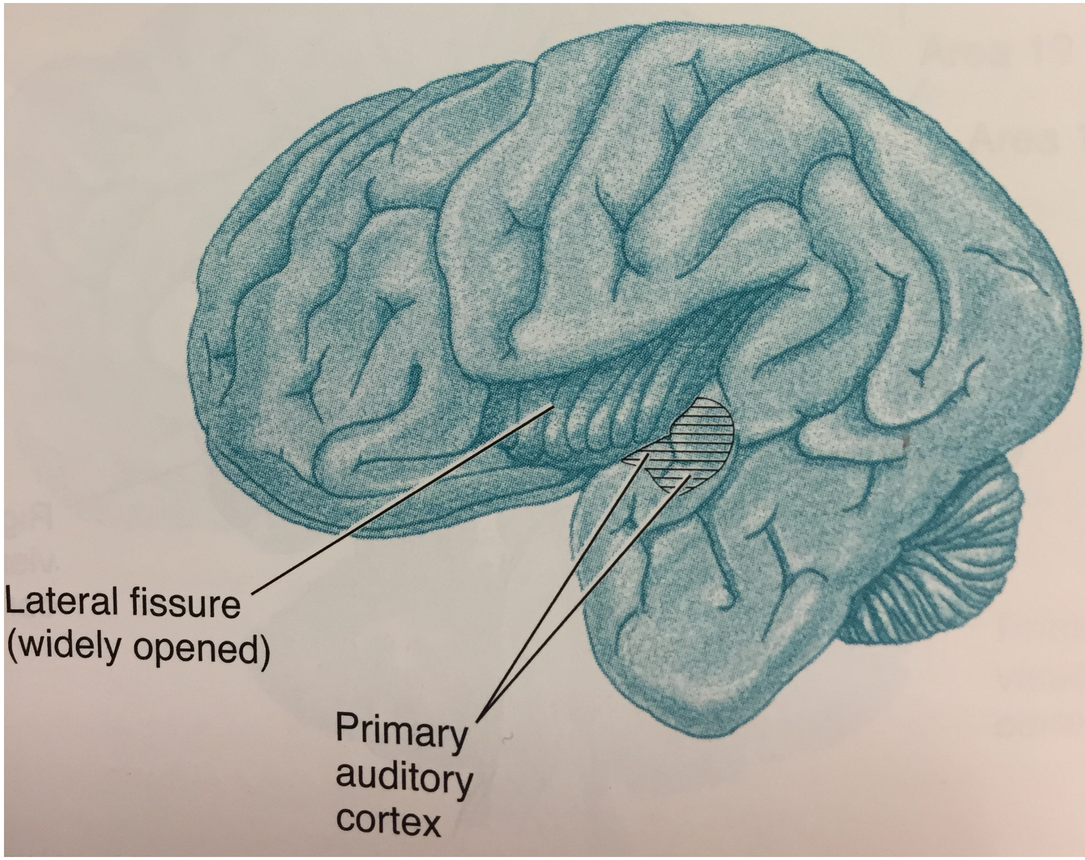
White Matter Tracts (IV)



Bozkurt B. et al. J Clin Neurosci 2016

Temporal Functional Cortical Anatomy

- Primary auditory cortex: Brodmann areas 41 & 42, transverse temporal gyri of Heschl
- Primary auditory association cortex: Brodmann area 22, superior temporal gyrus (Wernicke's area in the dominant hemisphere)



Language Cortex

Cortical mapping is of paramount importance for avoiding language-associated cortical areas

Cortical language localization in left, dominant Hemisphere. An electrical stimulation mapping investigation in 117 patients

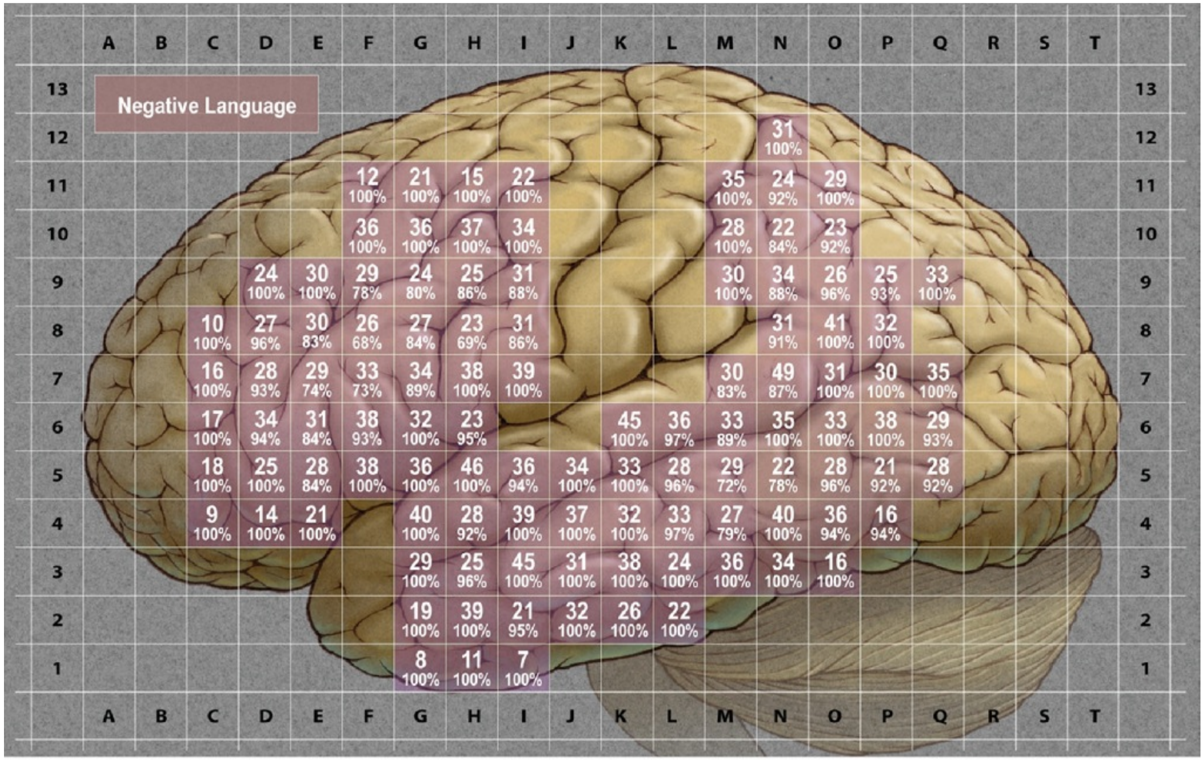


FIG. 2. Negative language map indicating the percentage of negative stimulations per square centimeter of the dominant cerebra hemisphere.

G OJEMANN, J OJEMANN,
E. LETTICH, M. BERGER.
J Neurosurg 71:316-326, 1989/2008

Outlining of Language-Associated Cortical Areas

Electrophysiological mapping:

- **Direct Electrical Cortical Stimulation (DCS)**

Intraoperative monopolar or bipolar direct cortical stimulation via awake craniotomy

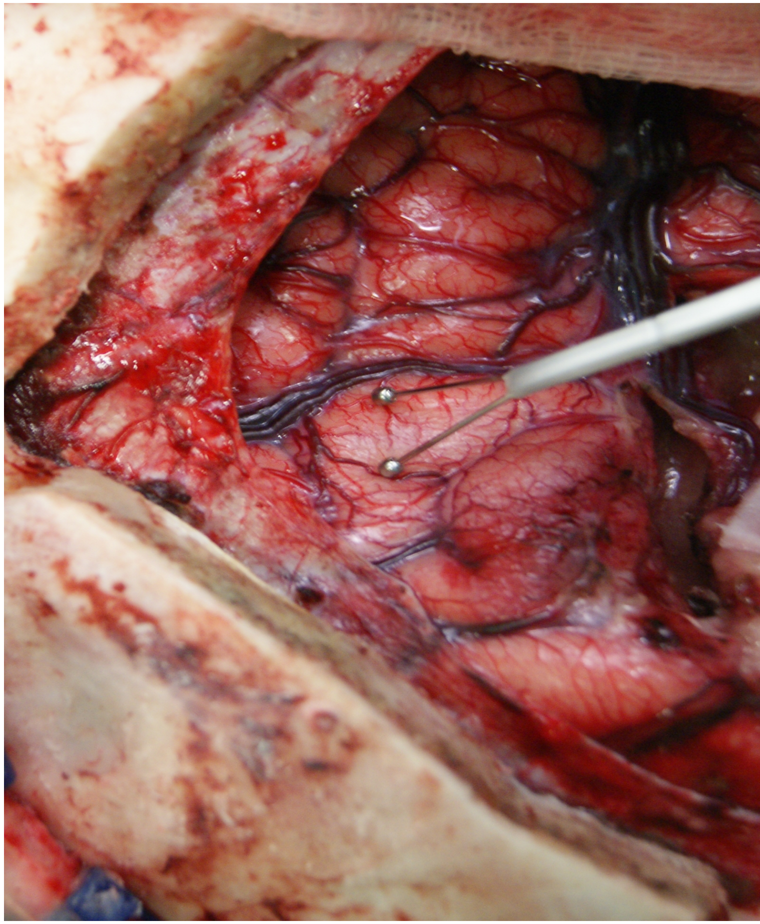
Extra-operative cortical stimulation

Cortical Mapping via DCS

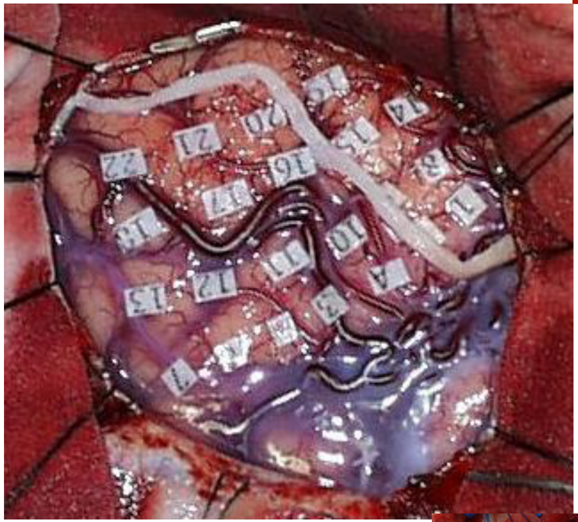
Intraoperative

Asleep-awake-asleep anesthesia

Cortical & subcortical mapping via bipolar stimulation

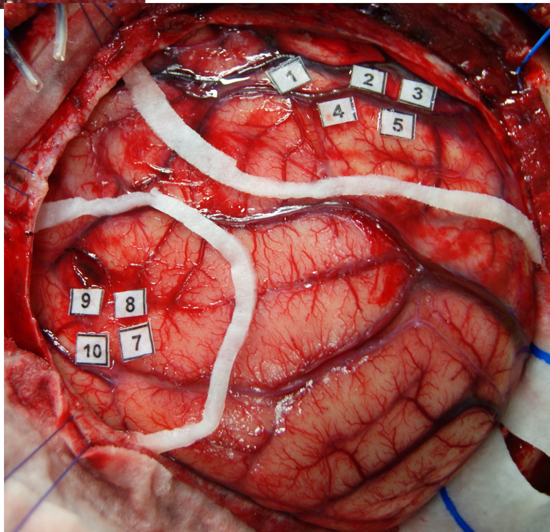


Cortical & Subcortical Mapping via Awake Craniotomy



Requirements:

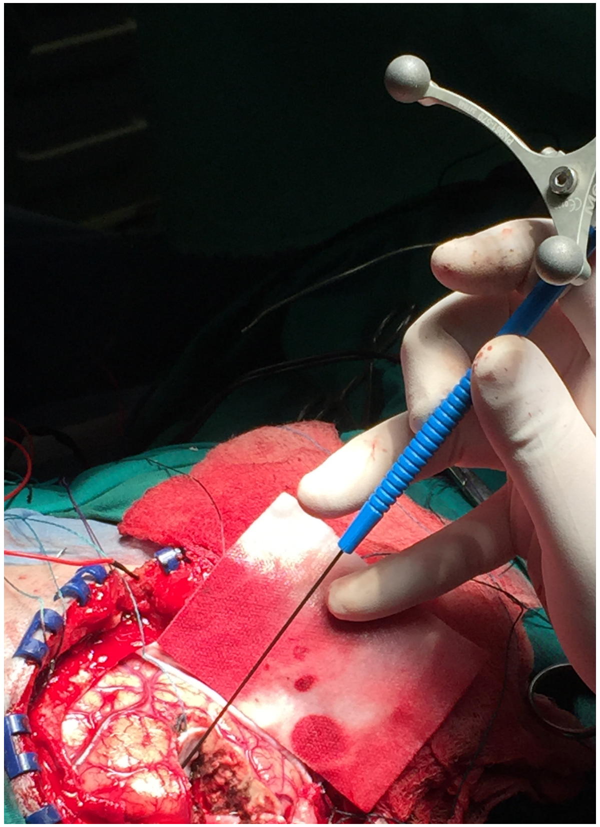
- Adult pt mostly
- Awake & cooperative pt
- Cooperative anesthesiologist
- Analgesia monitored anesthesia
- Significant operative time



Cortical & Subcortical Mapping via Awake Craniotomy

Limitations:

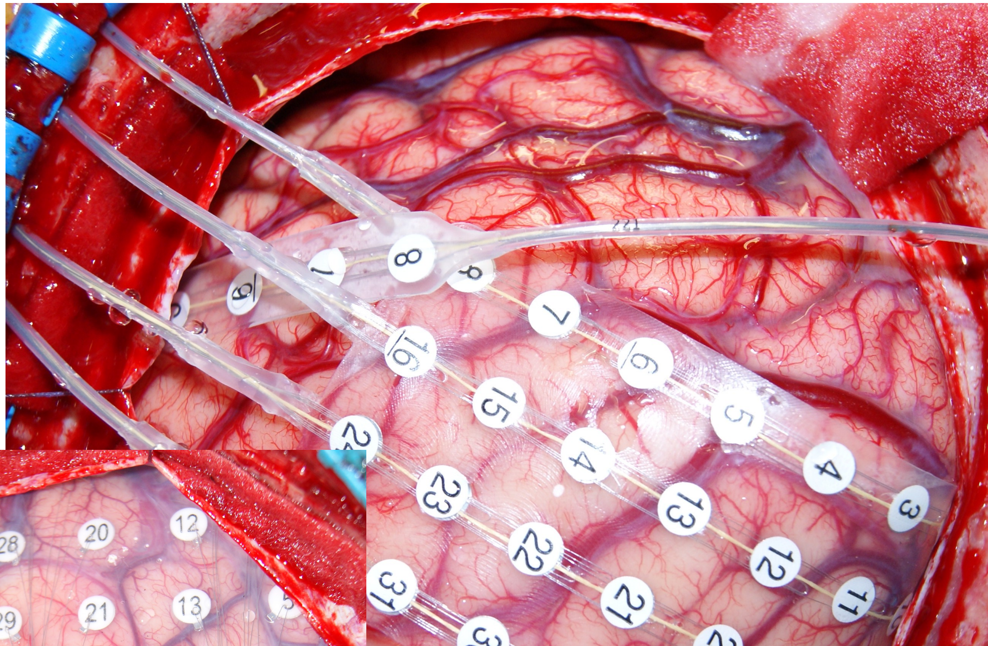
- Obesity, sleep apnea
- Midline brain structure shift
- Respiratory difficulties, heavy smoking
- Limited number of language paradigms
- Uncomfortable pt's position

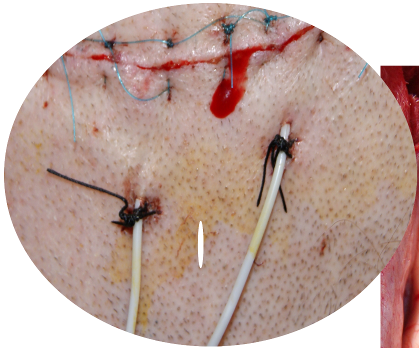


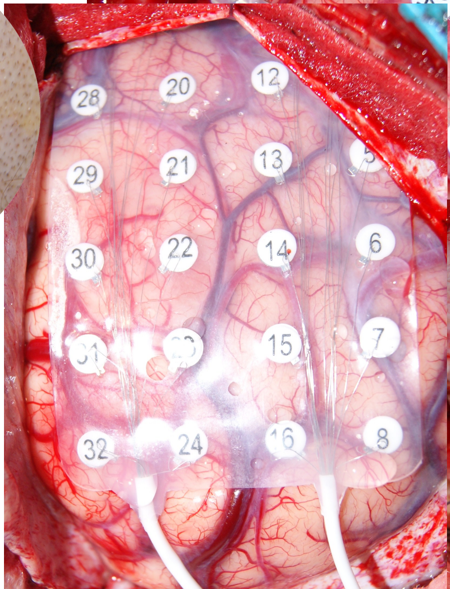
Cortical Mapping via Extraoperative Stimulation

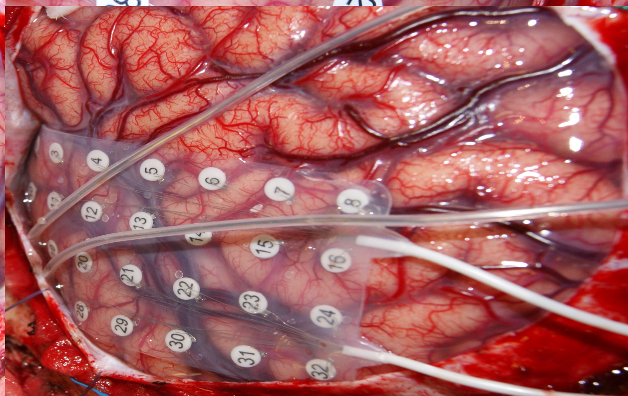
Procedures:

- Implantation of subdural grid, strip, and/or depth electrodes
- Securing of electrodes
- Surgical wound closure in anatomical layers





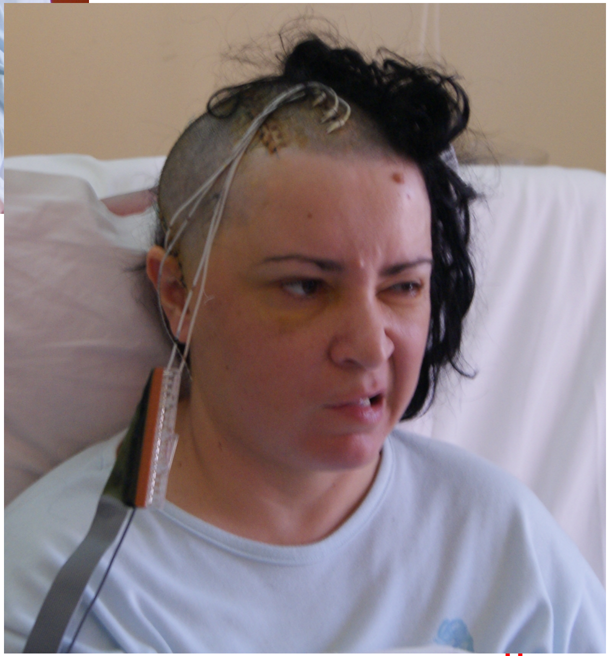




Mapping via Extraoperative Stimulation

Procedure:

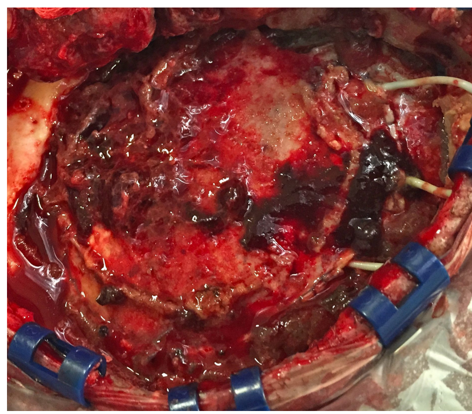
- Extraoperative cortical stimulation & mapping
- Comfortable process with wide awake, and cooperative pt
- Easier seizure mgmt
- Unlimited language & other neuropsychological tests

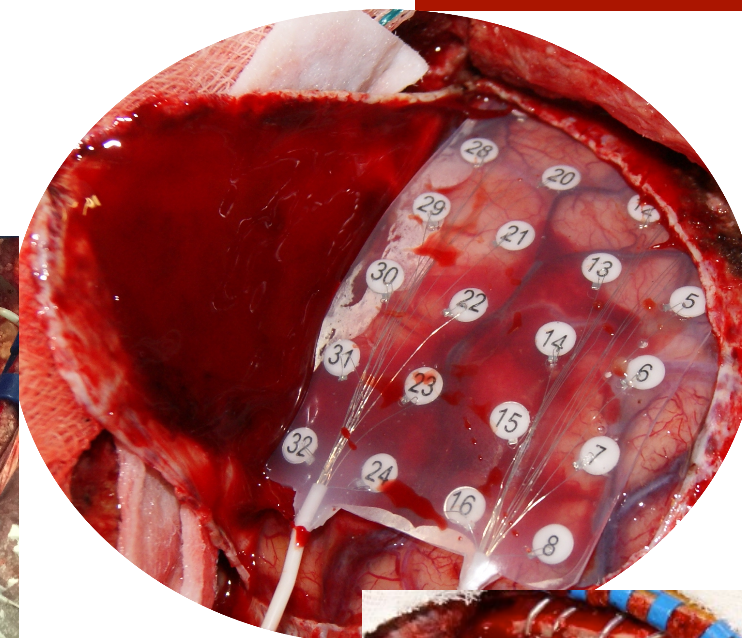


Mapping via Extraop Stimulation

Complications:

- Brain edema 0.5-14%
- EDH development 1.8-2.5%
- SDH formation 1.1-14%
- Infection 1.1-17%
- CSF leakage 0-20%





- Non-habitual sz recording up to 2.7%

Only 3.4% of complications required surgery

Neurosurg Clin N Am. 2011 Oct;22(4):519-31

Implanted subdural electrodes: safety issues and complication avoidance.

Fountas KN

Extra vs. Intraoperative Stimulation

ADVANTAGES

- Feasible in pediatric, and non-cooperative adult pts
- Unlimited language tests, multi-lingual test possible
- Better stimulation-associated seizure mgmt
- Comfortable pt
- Cortical mapping

  along EEG recording

DISADVANTAGES

- Two surgical procedures are required
- Theoretical increased risk of infection
- Subdural electrode associated complications
- Questionable increased procedural cost
- Inability to perform subcortical stimulation

Temporal Functional Cortical Anatomy

- **Prosopagnosia**: inability to recognize faces, cars, types of trees). Mostly occurred in cases of dominant temporal resections.
- **Kluver-Bucy syndrome** (**Terzian & Ore syndrome**): blunted affect with apathy, psychic blindness, hypermetamosphosis, hypeorarality, bulimia, hypersexuality
- **Recent memory deficits** after mesial temporal structure resection/ hippocampectomy