The Superior Frontal Transsulcal Approach to the Anterior Ventricular System: Exploring the Sulcal and Subcortical Anatomy Using Anatomic Dissections and Diffusion Tensor Imaging Tractography

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■ OBJECTIVE: **To explore the superior frontal sulcus (SFS) morphology, trajectory of the applied surgical corridor, and white matter bundles that are traversed during the superior frontal transsulcal transventricular approach.**

■ METHODS: **Twenty normal, adult, formalin-fixed cerebral hemispheres and 2 cadaveric heads were included in the study. The topography, morphology, and dimensions of the SFS were recorded in all specimens. Fourteen hemispheres were investigated through the fiber dissection technique whereas the remaining 6 were explored using coronal cuts. The cadaveric heads were used to perform the superior frontal transsulcal transventricular approach. In addition, 2 healthy volunteers underwent diffusion tensor imaging and tractography reconstruction studies.**

■ RESULTS: **The SFS was interrupted in 40% of the specimens studied and was always parallel to the interhemispheric fissure. The proximal 5 cm of the SFS (starting from the SFS precentral sulcus meeting point) were found to overlie the anterior ventricular system in all hemispheres. Five discrete white matter layers were identified en route to the anterior ventricular system (i.e., the arcuate fibers, the frontal aslant tract, the external capsule, internal capsule, and the callosal radiations). Diffusion tensor imaging studies confirmed the fiber tract architecture.**

■ CONCLUSIONS: **When feasible, the superior frontal transsulcal transventricular approach offers a safe and effective corridor to the anterior part of the lateral ventricle because it minimizes brain retraction and transgression and offers a wide and straightforward working corridor. Meticulous preoperative planning coupled with a sound microneurosurgical technique are prerequisites to perform the approach successfully.**

INTRODUCTION

Surgery of the anterior part of the ventricle remains a distinct challenge in neurosurgery because of its complex regional neurovascular anatomy[1-5] and because there is still controversy surrounding the most versatile operative corridor for each case. Traditionally, the 2 most commonly used surgical approaches have been the transcortical and transcallosal pathways, both of which offer direct and effective access with what was previously believed to be minimal brain transgression.[6-14]

However, the microneurosurgical concept of using normal cerebral corridors, such as fissures, cisterns, and sulci, to resect deep-seated lesions[15-21] has led to the evolution of a theoretically more delicate approach to the anterior part of the lateral ventricle and foramen of Monro through the superior frontal sulcus (SFS), known as the superior frontal transsulcal

Key words
- DTI
- Frontal lobe
- Transsulcal approaches
- Ventricular surgery
- White matter anatomy

Abbreviations and Acronyms
DTI: Diffusion tensor imaging
FAT: Frontal aslant tract
MRI: Magnetic resonance imaging
ROI: Region of interest
SFS: Superior frontal sulcus
SLF: Superior longitudinal fasciculus

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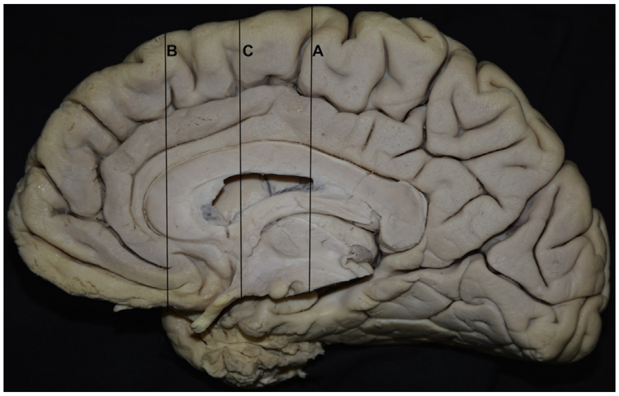

Figure 1. The medial surface of a left hemisphere. The black lines represent the levels of coronal cuts made. *A*, level of the intersection point of the precentral—superior frontal sulcus; *B*, level of the genu of the corpus callosum; *C*, middle of the distance between the 2 aforementioned levels.

transventricular approach.[16,22] During this approach, meticulous sulcal dissection is performed to minimize normal brain violation and permit optimal access to the ventricles. This ventricular operative variant has become more popular particularly because of the incorporation of sophisticated neuroimaging into everyday neurosurgical practice.

Neurosurgeons seem to have a gross and rather vague understanding of the lateral frontal lobe anatomy both in terms of surface morphology and underlying white matter architecture. More specifically and in the context of the superior transsulcal transventricular approach, data about the accurate topography and internal configuration of the SFS along with detailed knowledge of the fiber pathways transgressed during the approach are lacking in the neurosurgical literature. Hence, our main objective was to shed light on these issues by exploring the relevant anatomy both in cadaveric specimens through laboratory dissections and in normal individuals by using diffusion tensor imaging (DTI) studies.

To our knowledge, this is the first anatomic and imaging description of the superior frontal transsulcal approach aiming to provide a thorough three-dimensional understanding of the regional cortical and subcortical architecture for surgical practice.

METHODS

The study was divided into 2 parts and included laboratory cadaveric dissections and DTI imaging in normal individuals.

In the first part of the study, we used 20 normal, adult, cadaveric cerebral hemispheres (12 right hemispheres, 8 left hemispheres) obtained from 20 different cadavers, previously fixed in a 10%—15% formalin solution for a minimum period of 2 months. Arachnoid membrane and vessels were carefully removed and the topography, morphology, and dimensions of the SFS were thoroughly studied and recorded in all specimens. The SFS was defined as the sulcus demarcating the superior from the middle frontal gyrus, originating adjacent (posterior, anterior, or coincident) to the precentral sulcus and terminating close to the frontal pole.[23,24] The presence of a medial and/or middle frontal sulcus, which can add uncertainty to the proper identification of the SFS, was also recorded and their respective distance from the interhemispheric fissure was measured to clarify the surface anatomy of the lateral frontal lobe.

Fourteen hemispheres underwent the Klingler procedure and were explored through the fiber microdissection technique. The aim was to investigate and show the white matter pathways lying in or adjacent to the surgical corridor applied during the superior transsulcal transventricular approach. Ten specimens were dissected in a lateromedial direction,[25,26] 2 specimens were dissected in a mediolateral direction so as to show the anterior callosal fibers more accurately, and the remaining 2 hemispheres were explored both in a lateromedial and mediolateral direction to show the intermingling fibers of the corpus callosum and internal capsule at the level of the SFS.

Six specimens were investigated through coronal cuts made at 3 different levels along the length of the sulcus (Figure 1). The first cut was placed at the level of the SFS—precentral sulcus meeting point. The second cut was made at the level of the genu of the corpus callosum, which demarcates the anterior limit of the lateral ventricle, and the third cut was made in the middle between the 2 previous cuts. The rationale was to isolate and

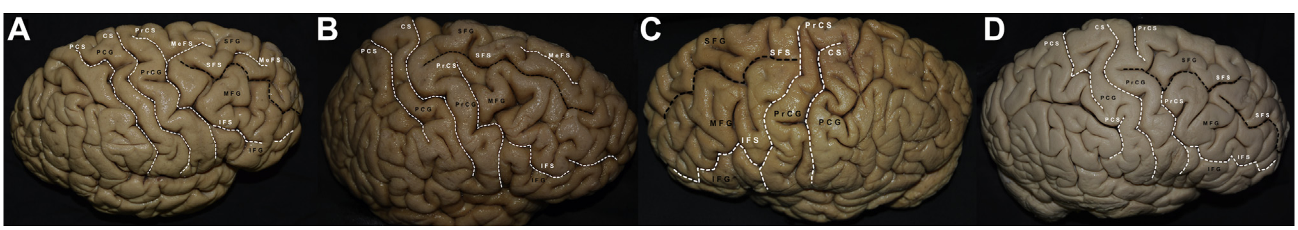

Figure 2. Three different hemispheres showing the morphologic variability of the superior frontal sulcus (SFS) and regional surface anatomy of the superolateral frontal lobe. (**A**) A right cerebral hemisphere showing an interrupted SFS with its originating point anterior to the precentral sulcus. An interrupted medial frontal sulcus is also apparent. (**B**) In this specimen, the SFS has a continuous pattern and its originating point lies posterior to the precentral sulcus. Note the presence of a prominent interrupted medial frontal sulcus. (**C**) A left hemisphere showing a continuous SFS with its originating point coincident to the precentral sulcus. (**D**) A right hemisphere with an interrupted SFS and its originating point posterior to the precentral sulcus. CS, central sulcus; IFG, inferior frontal gyrus; IFS, inferior frontal sulcus; MeFS, medial frontal sulcus; MFG, middle frontal gyrus; PCG, postcentral gyrus; PCS, postcentral sulcus; PrCG, precentral gyrus; PrCS, precentral sulcus; SFG, superior frontal gyrus.