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Original Article

Frontal aslant tract: Anatomy and tractography description in the Mexican population

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ABSTRACT

Background: The aim of the study was to describe the origin, course, and termination of frontal aslant tract (FAT) in the Mexican population of neurosurgical referral centers.

Methods: From January 2018 to May 2019, we analyzed 50 magnetic resonance imaging (MRI) studies in diffusion tensor imaging sequences of patients of the National Institute of Neurology and Neurosurgery "Manuel Velasco Suárez." Five brains were fixed by the Klingler method and dissected in the neurosurgery laboratory of the Hospital Civil de Guadalajara to identify the origin, trajectory, and ending of the FAT.

Results: FAT was identified in 100% of the MRI and brain dissections. The origin of the FAT was observed in 63% from the supplementary premotor area, 24% from the supplementary motor area, and 13% in both areas. Its ending was observed in the pars opercularis in 81%, pars triangularis in 9%, and in both pars opercularis and ventral premotor area in 10% in the magnetic resonance images, with a left side predominance. In the hemispheres dissections, the origin of FAT was identified in 60% from the supplementary premotor area, 20% from the supplementary motor area, and 20% in both areas. Its ending was observed in the pars opercularis in 80% and the pars triangularis in 20%. It was not identified as an individual fascicle connected with the contralateral FAT.

Conclusion: In the Mexican population, FAT has a left predominance; it is originated more frequently in the supplementary premotor area, passes dorsal to the superior longitudinal fascicle II and the superior periinsular sulcus, and ends more commonly in the pars opercularis.

Keywords: Frontal aslant tract, Klingler, Neurosurgery laboratory, Tractography, White matter fibers

INTRODUCTION

Technological advances in neuroimaging, such as magnetic resonance imaging (MRI), have been developed to allow precise descriptions and quantification of the cerebral tracts through diffusion tensor imaging (DTI) tractography.

One of the latest described pathways is the frontal aslant tract (FAT); it was first described in 2008 by two independent groups that studied white matter tracts, whose name is derived from its oblique shape.[13] This tract consists of short connections among the posterior area of the Inferior

Frontal Gyrus (IFG), specifically, the pars opercularis and triangularis with the Superior Frontal Gyrus (SFG) and cingulate gyrus: the pre-supplementary motor area (pre-SMA), SMA and the anterior cingulate cortex.[3,16]

In many studies, FAT has been observed in both hemispheres, but with a left predominance; besides, the most of the FAT fibers originate at pars opercularis; in that way, it is associated with language and speech processes.[4,6] FAT disconnection relates to stuttering, progressive aphasia, or arrest that can recover spontaneously from days to months later.[9,15]

Our study aims to describe the morphology and pathway of the FAT in the Mexican population, from its origin to its termination, the relationship with adjacent white matter tract, and their prevalence in the DTI sequence of MRI as in dissection of cerebral hemispheres.[10]

MATERIALS AND METHODS

We analyzed 50 MRI studies in DTI sequences (100 cerebral hemispheres) of patients of the National Institute of Neurology and Neurosurgery (INNN) from January 2018 to May 2019. The images were obtained from a General Electric resonator 1.5T, where FAT was delimited by fibertracking at a BrainLab Workstation. Informed consent was requested from each patient regarding the use of their imaging study. The origin, course, termination, and communication to the contralateral hemisphere were observed. On the other hand, five brains (10 cerebral hemispheres) were fixed in 10% formalin per 2 months and then frozen at -7° for 2 weeks as described by Klingler in the experimental neurosurgery laboratory of the Hospital Civil de Guadalajara "Fray Antonio Alcalde," where the FAT was dissected.[1] Its origin, course, and termination were compared and its relationship with the upper longitudinal fascicle, the claustrocortical fibers, and its passage through the superior periinsular sulcus. Microsurgical techniques dissection was performed under ×6 to ×40 magnifications provided by a Zeiss Surgical Microscope (Carl Zeiss OPMI® Vario S88 Oberkochen, Germany). Fiber tracts were dissected with homemade wooden sticks, microdissectors, and fine forceps.

RESULTS

In the 50 magnetic resonance images analyzed (100 hemispheres), the FAT was identified in 100% of the cases. The origin of FAT was 63% from the supplementary premotor area, 24% from the SMA, and 13% were found in both areas. The FAT was located dorsal to the superior periinsular sulcus in 100% of cases; it ends in the pars opercularis in 81%, pars triangularis in 9%, and in both pars opercularis and ventral premotor area in 10% of cases. Lateralization was presented to the left side in 92% of cases. Connections to the contralateral hemisphere were found in 98%; however, only 75% of the studies connected a tract directly with the contralateral FAT [Figure 1].

In the ten dissected hemispheres, FAT could be detected in 100%. It originated from the supplementary premotor area in 6 hemispheres (60%), from the SMA in 2 hemispheres (20%), and both areas in 2 hemispheres (20%). The tract was located dorsal to the superior longitudinal fascicle II and the superior periinsular sulcus in 100% of the dissections, while the pathways of the claustrocortical fibers were below this sulcus and entered the central core. The FAT ended up in the pars opercularis in 8 hemispheres (80%) and the pars triangularis in 2 (20%). In 10 hemispheres, it was possible to determine connections to the contralateral hemisphere through the corpus callosum; however, it was impossible to identify an individual fascicle connected with the contralateral FAT (crossed FAT) [Figure 2].

DISCUSSION

FAT was first described in 2008; in 2012, Catani defined the pathway and named it "aslant tract," derived from its oblique shape. It is known that it goes through both hemispheres, but the left lateralization has been noted.[5,7,11,12]

The FAT is not entirely studied and defined. In this research, we want to emphasize the importance of surgical aspects in awake patients with frontal tumors that infiltrate FAT and the association of speech arrest, the variability of the anatomical origin and ending, and connections to contralateral hemispheres.[6,10]

This tract is very useful for understanding the SMA syndrome. It consists of contralateral transient weakness and akinesia to the side of the affected hemisphere, associated with lesions in SMA, especially in Brodmann's areas 6 and 8.[14]

The SMA syndrome is common posterior to the resection of an intrinsic tumor located in the premotor and SMA; thus, we can explain the resolution of the paresis, weakness, and language deficits in a matter of weeks to months after surgery.[2,8] The SMA syndrome's recovery has been associated with neuronal plasticity through connections to the contralateral hemisphere.[14] Some authors have described the "crossed FAT" and related it to the recovery of the SMA syndrome; nonetheless, in this study, we could not identify it.[9]

To the best of our knowledge, this is the first study in the Mexican population, in which we can corroborate the existence of the FAT in the total of the hemispheres analyzed and identify its origin in more than half of cases from pre-SMA and its termination predominantly in pars opercularis of the IFG, as the current literature refers.

Likewise, we were able to identify the contralateral FAT in imaging studies but not in brain dissections. We consider that

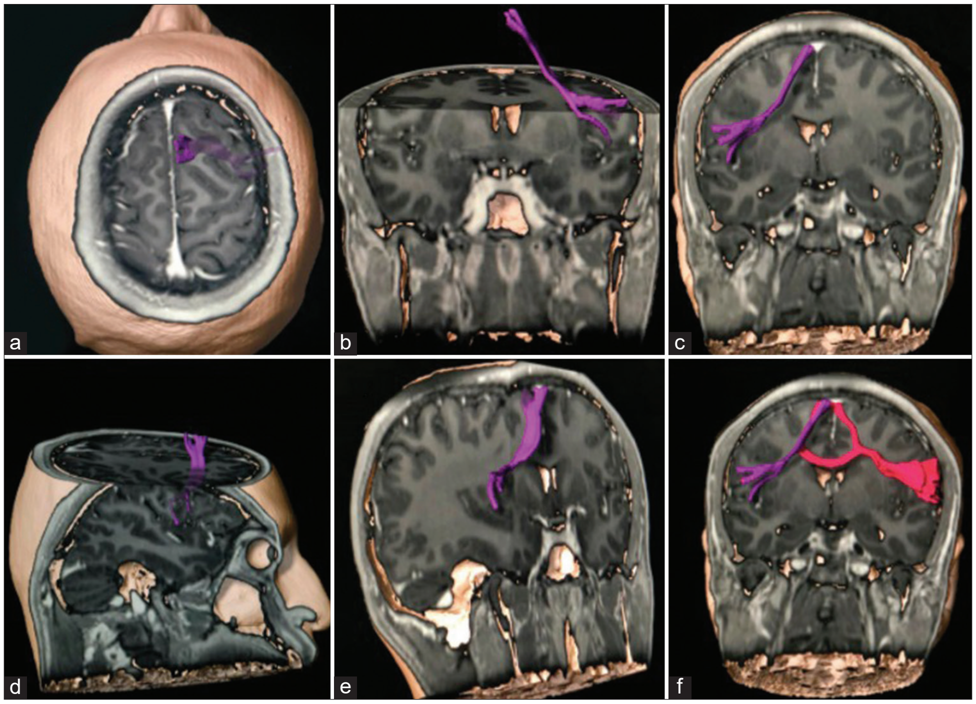

Figure 1: Diffusion tensor imaging tractography. (a) Origin of the right frontal aslant tract (FAT) (purple) in the supplementary premotor area. (b) Anterior view of the left ending of the FAT (purple) in the inferior frontal gyrus. (c) Posterior view and trajectory of the left FAT (purple). (d) Lateral view of the ending of the right FAT (purple) in the pars opercularis. (e) Ending of the right FAT (purple) in the pars triangularis. (f) Posterior view of the left FAT (purple) trajectory and right FAT (pink) with a connection through the corpus callosum.

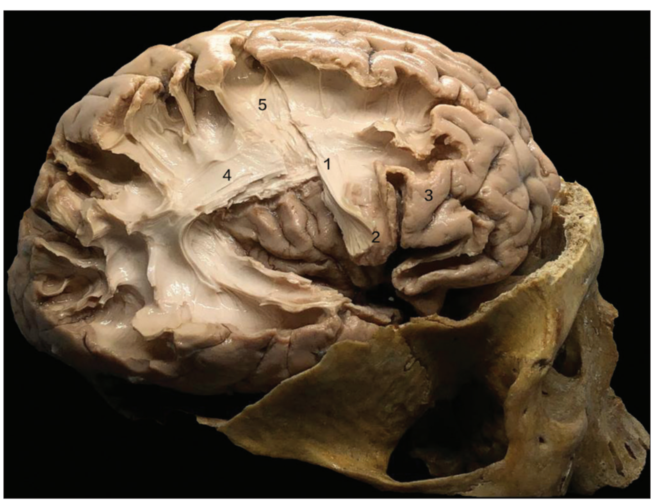

Figure 2: Lateral view of the frontal aslant tract dissection with Klingler's technique. (1) Frontal aslant tract. (2) Pars opercularis. (3) Pars triangularis. (4) Superior Longitudinal Fascicle II. (5) Claustrocortical fibers.

the importance of this tract lies, mainly, in the knowledge of its anatomy, origin, and termination, especially in brain tumors surgeries of the frontal lobe, since the SMA syndrome or even language arrests are not uncommon following frontal lobe surgeries, and the most of these complications present spontaneous resolution over time.

CONCLUSION

The FAT in the Mexican population presents predominantly left lateralization and discurs from the supplementary premotor area following a dorsal trajectory to the superior longitudinal fascicle II and the superior periinsular sulcus, to the pars opercularis as its termination. There is still more to discover about the functionality of this tract, so further studies with the use of MRI-DTI have to be carried out to expand this knowledge in the neurosurgical area.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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