CORTEX 56 (2014) 145–156

Available online at www.sciencedirect.com

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Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

Intralobar fibres of the occipital lobe: A post mortem dissection study

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ARTICLE INFO

Article history:
Received 30 October 2013
Reviewed 21 December 2013
Revised 16 February 2014
Accepted 5 March 2014
Published online 22 March 2014

Keywords:
Occipital lobe
White matter
Fibre tracts
Klingler technique

ABSTRACT

Introduction: The atlas by Heinrich Sachs (1892) provided an accurate description of the intralobar fibres of the occipital lobe, with a detailed representation of the short associative tracts connecting different parts of the lobe. Little attention has been paid to the work of Sachs since its publication. In this study, we present the results of the dissection of three hemispheres, performed according to the Klingler technique (1935). Our anatomical findings are then compared to the original description of the occipital fibres anatomy as detailed by Sachs.
Methods: Three hemispheres were dissected according to Klingler's technique (1935). Specimens were fixed in 10% formalin and frozen at −15 °C for two weeks. After defreezing, dissection of the white matter fibres was performed with blunt dissectors. Coronal sections were obtained according to the cuts originally described by Sachs. In addition, medial to lateral and lateral to medial dissection of the white matter of the occipital lobe was also performed.
Results: A network of short association fibres was demonstrated in the occipital lobe, comprising intralobar association fibres and U-shaped fibres, which are connecting neighbouring gyri. Lateral to the ventricles, longitudinal fibres of the stratum sagittale were also identified that are arranged as external and internal layers. Fibres of the forceps major were also found to be in direct contact with the ventricular walls. We were able to replicate all tracts originally described by Sachs. In addition, a previously unrecognised tract, connecting the cuneus to the lingual gyrus, was identified. This tract corresponds to the "sledge runner", described in tractography studies.
Conclusions: The occipital lobe shows a rich network of intralobar fibres, arranged around the ventricular wall. Good concordance was observed between the Klingler dissection technique and the histological preparations of Sachs.

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http://dx.doi.org/10.1016/j.cortex.2014.03.002
0010-9452/

The present work is the first contribution to a series of publications dedicated to the investigation of the brain and its functions in health and pathology. This field of research is still heavily under investigated and nearly every contribution to it is a step forward similar to an expedition into unknown territory comparable to the "deepest Africa".

C. Wernicke, introduction to Sachs's atlas

Breslau, 1892

1. Introduction

When it was published, the atlas of Heinrich Sachs ("*The hemispheric white matter of the human brain. Part I: The occipital lobe*", 1892) was saluted by his mentor Wernicke with great enthusiasm. It represented the most accurate description of the intralobar fibres of the occipital lobe ever provided in humans, with a particularly detailed representation of the short associative tracts connecting different portions of the lobe (Fig. 1). At the end of the 19th century, the study of white matter anatomy was revolutionised by the introduction of microscopy and histological preparations of cerebral specimens (Schmahmann and Pandya, 2009). Brains collected at autopsy were fixed, initially using alcohol or chromic acid and only later with formaldehyde. Once the fixation process was completed, thin sections were obtained using the microtome ("*as thin as the microtome allows*" as stated by Sachs). The hereby obtained slices were stained and scrutinised under the microscope, to reveal the complex organisation in layers and fascicles of the white matter. Great neuroanatomists of the time, including Meynert (1833–1892), Flechsig (1847–1929) and Wernicke (1848–1900), applied these novel histological techniques to investigate white matter anatomy (Catani, Forkel, & Thiebaut de Schotten, 2010). Heinrich Sachs, under the tutorage of Wernicke, applied the histological method to the detailed study of the white matter of the occipital lobe. His method consisted of preparing the sections with celloidin, and then treating them with the Pal-haematoxylin and the picrocarmine stains (the former being a specific myelin stain) (Whethered, 1888, Forkel et al., 2014). Surprisingly, little attention has been paid to the work of Sachs after; one reason being that his work was only available in German. The importance of the anatomy and function of the short associative fibres – emphasised in the work of Sachs – has also long been neglected (Catani et al., 2012).

Less than half a century after the publication of Sachs' atlas, a new technique was developed by Joseph Klingler (1935). Working as an anatomical preparator at the University of Basel (Switzerland), Klingler introduced the process of freezing the brains previously fixed in formalin (Agrawal et al., 2011). The freezing process is a crucial step, since the ice that forms between the fibres separates the white matter fascicles, thus facilitating the dissection. The Klingler method greatly improved the techniques of gross dissection of the white matter of the brain, allowing for more accurate anatomical investigations (Ludwig & Klingler, 1956).

In recent years, the advancement of novel in vivo magnetic resonance imaging (MRI) techniques, such as diffusion imaging tractography (Catani & Thiebaut de Schotten, 2008; Jones, Simmons, Williams, & Horsfield, 1999; Le Bihan et al., 2001) and the resurgence, particularly in the neurosurgical community, of post mortem dissection according to the Klingler method (Türe, Yaşargil, Friedman, & Al-Mefty, 2000) has reignited an interest in the study of white matter anatomy. In the last decade, several fibre dissection studies have been reported, providing original anatomical data (Fernandez-Miranda et al., 2008; Martino, Vergani, Robles, & Duffau, 2010; Peltier et al., 2010) and elucidating the cortical termination of some controversial fascicles (Martino, Brogna, Robles, Vergani, & Duffau, 2010; Sarubbo, De Benedictis, Maldonado, Basso, & Duffau, 2011).

In this work, we present original data obtained according to the Klingler dissection of three neuroanatomically healthy

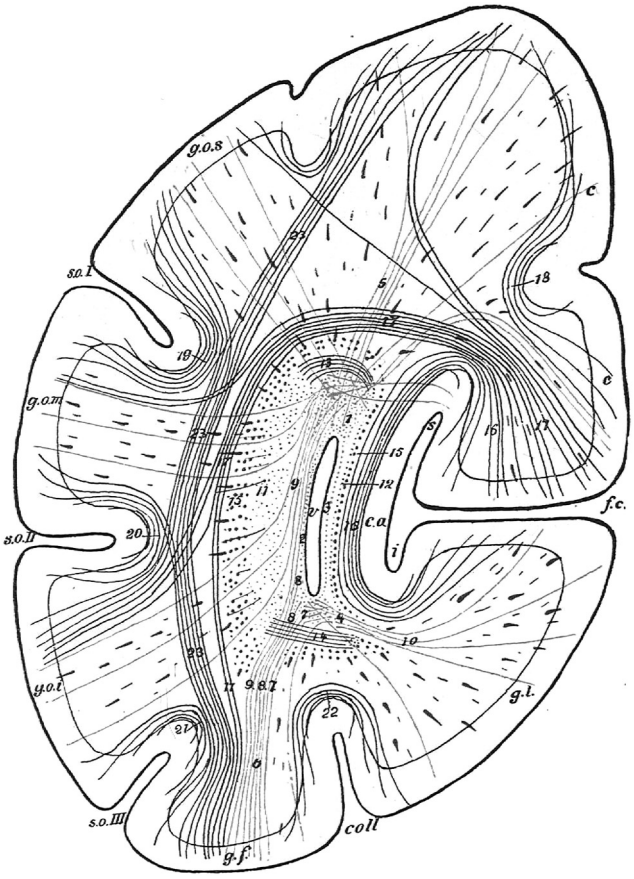

Fig. 1 – Schematic representation of the intralobar white matter fibres of the occipital lobe provided by Sachs (1892). Frontal section through a right hemisphere. *v*: ventricle (occipital horn); *f.c.*: fissura calcarina (calcarine fissure); *coll.*: collateral sulcus; *s.o.I*: sulcus occipitalis superior, *s.o.II*: sulcus occipitalis medium; *s.o.III*: sulcus occipitalis inferior; *g.l.*: gyrus lingualis; *g.f.*: gyrus fusiformis; *g.o.s.*: superior occipital gyrus; *g.o.m.*: middle occipital gyrus; *g.o.s.*: superior occipital gyrus; 1–10: forceps; 11–14: stratum sagittale internum; 15: stratum sagittale externum; 16: stratum calcarinum; 17: stratum cunei transversum; 18: stratum proprium cunei; 19: stratum proprium s.o.I; 20: stratum proprium s.o.II; 21: stratum proprium s.o.III; 22: stratum proprium coll.; 23: stratum profundum convexitatis.