

OCCIPITAL LOBE MORPHOLOGICAL ANATOMY

Anatomical and surgical aspects

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ABSTRACT - Background: The occipital lobe is an important region of the central nervous system and site of a wide variety of lesions. Different from others regions of the brain, whose anatomy has been already meticulously detailed, controversies about occipital lobe morphology can occasionally hinder the surgical approaches to it. **Method:** Twenty-six hemispheres were dissected, examining the distances of the medial structures of the posterior interhemispheric fissure region; identifying the sulci and gyri more frequently found in the lateral surface; and detailing the anatomy of the occipital horn of the lateral ventricle. Also, anatomical details of structures such as the calcarine sulcus and preoccipital notch were evaluated. **Results:** Twenty-four hemispheres (92%) showed sulci with evident transverse trajectories in the lateral surface, and it was possible to identify marked longitudinal sulci in 16 (61%). All of the specimen presented a transverse sulcus in the inferior third of the lobe – labeled in this paper as Inferior Transverse Occipital – and 69% of the cases showed a transverse sulcus in the superior third – labeled as Superior Transverse Occipital. The occipital horn was present in 53% of the cases at level of the anterior boundary of the lobe. It was a half moon shaped cavity, whose the medial wall was formed by the *calcar avis* and the lateral wall, roof and floor formed by fibers of the *tapetum*. **Conclusion:** The occipital lobe presents parameters that are often recognized in most of the dissected brain and can be useful for the planning and performance of surgery in this area of the brain.

KEY WORDS: occipital lobe, anatomy, surgery.

Anatomia morfológica do lobo occipital: aspectos anatômicos e cirúrgicos

RESUMO - Introdução: O lobo occipital é uma importante região do sistema nervoso central e local de ocorrência de ampla variedade de patologias. Diferente de outras regiões do cérebro, cuja anatomia já foi meticulosamente detalhada, ainda existem controvérsias a respeito do pólo occipital que ocasionalmente podem dificultar cirurgias sobre esta região. **Método:** Foram dissecados 26 hemisférios cerebrais, examinando-se distâncias de algumas estruturas localizadas na região da fissura interemisférica posterior, identificando os sulcos e giros mais frequentemente encontrados na face lateral do lobo occipital, e detalhando-se a anatomia do corno occipital do ventrículo lateral. Também foram avaliados detalhes anatômicos de estruturas como o sulco calcarino e incisura pré-occipital. **Resultados:** Em 24 hemisférios (92%) foram identificados sulcos com trajetos transversais evidentes na face lateral do lobo, sendo que sulcos longitudinais foram observados em 16 peças (61%). Em todas foi possível identificar um sulco transversal completo no terço inferior do lobo – denominado neste estudo como sulco transversal inferior – e 69% dos hemisférios demonstraram um sulco transversal no terço superior – denominado sulco transversal superior. O corno occipital estendia-se até o lobo occipital em apenas 53% das peças, e em todas apresentava-se como uma cavidade em forma de meia-lua, cuja parede medial era formada pelo *calcar-avis* e a parede lateral, teto e assoalho do ventrículo formada por fibras do *tapetum*. **Conclusão:** O lobo occipital apresenta parâmetros anatômicos que são reconhecíveis e repetidos na maioria dos cérebros dissecados. Estes parâmetros podem ser úteis na orientação de cirurgias realizadas nesta região do encéfalo.

PALAVRAS-CHAVE: lobo occipital, anatomia, cirurgia.

The occipital lobe is an important region of the central nervous system (CNS), responsible for the sense of vision. Studies of this lobe are usually centered in its sensory function and the integration of the visual pathways, and sometimes its morpho-

logical structure is overlooked¹⁻⁴. It is a posterior extension of the parietal lobe, arbitrarily divided due to its unique function and to facilitate research and studies on this region. The imposed limits give to the occipital lobe a triangular shape, delineated on

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Received 13 December 2001, received in final form 28 February 2002. Accepted 5 March 2002.

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the medial surface by the parieto-occipital (PO) sulcus; on the lateral surface by an imaginary line connecting the end of the PO sulcus to the preoccipital notch - labeled parieto-temporal lateral line; and the inferior face (tentorial) by another line that connects the preoccipital notch to the beginning of the PO sulcus (where it emerges from the calcarine sulcus) - labeled parieto-temporal basal line^{5,6}. As such, imposed by the set limits, all of the nervous structures localized posteriorly to then will be related to visual functions. In this lobe we can find the three Brodmann areas related to vision: 17, 18 and 19². There are few gyri delineated in the occipital lobe. On its medial surface, there is the cuneus, a gyrus localized between the calcarine sulcus and the PO sulcus. Inferior to the calcarine sulcus, in the tentorial surface of the lobe, there is the lingual gyrus. The collateral sulcus separates the lingual gyrus from the fusiform gyrus. The fusiform gyrus is delineated laterally by the occipitotemporal sulcus. For the lateral surface of the lobe the nomenclature is still not well defined, and most texts limits the description of this region as "diverse sulci and inconstant gyri"⁷⁻⁹. There is few agreement over the nomenclature of the sulci: the most commonly described is the lunar sulcus, a vertical sulcus identified in the occipital pole region. Among the transverse sulci, the most frequently cited are the occipital transverse and the lateral occipital sulci. Other authors describe the sulci of the lateral surface as the inferior and superior occipital^{6,10}.

The deep substance of the occipital lobe is composed of white matter formed by myelinated fibers that project or emerge from the visual cortex, and sometimes the occipital horn of the lateral ventricle can be found. The occipital horn walls usually are described as follows: the *tapetum* (fibers form the splenium of the corpus calosum) forming the roof and lateral wall, the floor is formed by the collateral eminence (corresponds to an indentation of the collateral sulcus on the ventricle), and the medial wall by the *calcar avis* (the deepest portion of the calcarine sulcus)¹¹ and the bulb of the corpus calosum (fibers from the splenium to the occipital lobe that form the superior aspect of the medial wall of the occipital horn)⁷.

The occipital lobe is site of a wide variety of lesions and sometimes surgeons need to directly approach it (such as resection of occipital gliomas) or go through it (such as in approaches to deep structures or ventricles, as pineal gland or splenium)¹²⁻¹⁶. The knowledge of the superficial morphological relations of this lobe and the identification of its spatial relationship facilitate the approach to subcorti-

cal lesions and permit safer access to deep structures. So, the identification and normalization of its structures is important, principally those related to the lateral surface of the lobe. The objective of this study is to anatomically map this region of the encephalon, to facilitate surgical procedures on this lobe.

METHOD

Thirteen autopsy specimen brains were dissected, totaling 26 hemispheres. The encephalon were fixed in a 4% solution of formaldehyde, using only those that did not exhibited post mortem manipulation or pathologies. Sex were not considered as exclusion criteria for this study. All the specimen were adult brain.

For the preparation of the specimen, the brain stem was sectioned at the level of the cerebral peduncles and the hemispheres separated by a midline sagittal section. The pia mater and blood vessels were delicately removed to expose the cerebral sulci, allowing better visualization. The dissection of each cerebral hemisphere was performed in a sequence of three steps. Initially, it was identified the medial surface structures of the hemisphere, principally identifying the total extension of the calcarine and PO sulci. After, it was marked some distances of interest in approaches to the interhemispheric fissure in its posterior region. All the distances were measured using the most posterior portion of the splenium as the principal reference point (Table 1). The second step consisted of the dissection of the lateral surface of the lobe, studying the sulcal pattern that were localized posteriorly to the lateral parieto-temporal line. In this step, the anatomy of the preoccipital notch was also studied. Finally, the lobe was separated from the rest of the brain making a section at the level of the PO sulcus medially, and laterally at the level of the parieto-temporal line. Measurements were made of the deep structures, principally the ventricular walls of the occipital horn. The depth of the principal sulci on the medial and lateral surfaces were also assessed. A second section was made ten millimeters posteriorly to the first one, and new measurements of the same structures were made.

Table 1. Distance measured in the posterior interhemispheric fissure in 26 anatomic specimen.

Distance	Average (mm)	Variation (mm)
Bifurcation ¹ - Splenium	22	16-19
Calcarine sulcus end - Splenium	58	48-64
Bifurcation ¹ - PO ² sulcus end	32	26-40
Bifurcation ¹ - Calcarine sulcus end	35	29-46
PO ² sulcus end - Splenium	47	41-50
PO ² sulcus end - Calcarine sulcus end	45	34-50

¹Bifurcation: emergence of the parieto-occipital sulcus at the calcarine sulcus. ²PO: parieto-occipital.

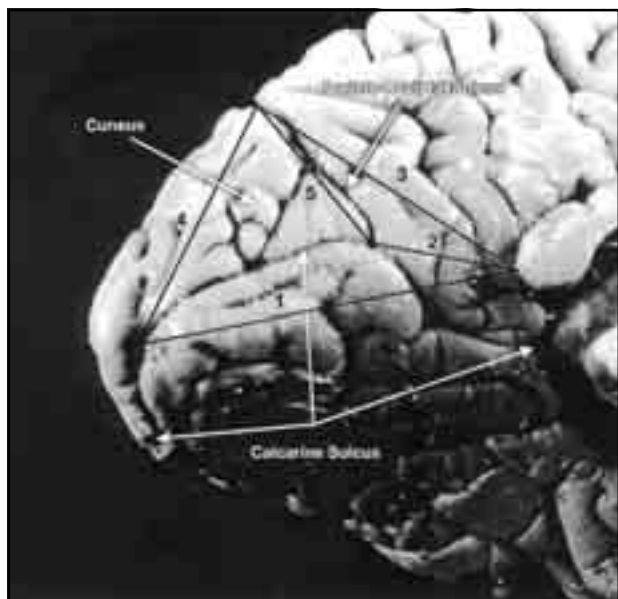


Fig 1. Distance measured on the medial surface of the occipital lobe: 1. splenium to calcarine sulcus end; 2. splenium to calcarine-PO* bifurcation; 3. splenium to PO* end; 4. PO* sulcus end to calcarine sulcus end; 5. PO*-calcarine sulcus bifurcation to PO* end. *Parieto-occipital.

RESULTS

It was observed that the calcarine sulcus emerged directly from the parahippocampal gyrus and was present as a complete sulcus in all of the hemispheres

examined. In 12 hemispheres, no side branches were observed (46%), in 10 there was just one (38%) and in 4 there were two side branches to the calcarine (15%). In relation to these side branches, 14 (77%) were observed with a perpendicular trajectory to the calcarine and 4 (23%) were in parallel trajectory. Eighty eight percent of the side branch sulci were identified posteriorly to the emergence of the PO sulcus.

Table 1 summarizes the results of the measured distances on the medial surface of the occipital lobe (Fig 1).

At the lateral surface of the occipital lobe, there was a determined pattern of sulci observed in most of the specimen. Twenty-four hemispheres (92%) showed sulci with evident transverse trajectories and in 16 hemispheres it was possible to identify marked longitudinal sulci (61%). All of the hemispheres in which transverse sulci were identified presented a sulcus localized on the inferior third of the lobe, and it was labeled as inferior transverse occipital sulcus. This one, in all of the specimens, presented as a complete sulcus. It was possible to identify a localized sulcus on the middle or superior third of the lobe in eighteen hemispheres (69%) – this was labeled superior transverse occipital sulcus – and this one was complete in only 10 hemispheres (55%). In just one case a third transverse sulcus was observed localized between the previously mentioned - labeled middle transverse occipital sulcus. Among the 16



Fig 2. Posterolateral view of the occipital lobe. ITO: inferior transverse occipital; MTO: medium transverse occipital; STO: superior transverse occipital.

Table 2. Depth of the occipital lobe sulcus measured (in millimeters) at the level of the parieto-occipital sulcus emergence (section 1) and ten millimetres posterior to the first one (section 2), in 26 cerebral hemispheres.

Sulci	section 1		section 2	
	Average	Variation	Average	Variation
Calcarine	20	15-25	15	9-15
Parieto-occipital	21	15-25	-	-
STO ²	15	10-18	14	8-18
ITO ¹	13	08-17	08	5-10

¹ITO: Inferior transverse occipital. ²STO: Superior transverse occipital.

hemispheres in which it was possible to identify longitudinal sulci, the lunar sulcus was identified in 12 (46% of the specimen). Most of the cases showed patterns of the transverse sulci that permitted a division of the occipital lobe into three gyri- inferior, middle and superior occipital (Fig 2).

Also, distances from the occipital pole to the pre-occipital notch were checked. This distance was largely heterogenic between the hemispheres, ranged from 30 to 61 mm (average 44). In all of them, the preoccipital notch corresponded to a deep indentation on the inferolateral border of the cortical surface, formed by the posterior portion of the inferior

temporal gyrus where it reaches the inferior occipital gyrus.

Table 2 shows the measured depths of the sulci in the first section made at the level of the PO sulcus and at the second section, ten millimeters posterior to the previous. There was a tendency that all of the sulci were deeper anteriorly, becoming shallower as they approached the pole. The occipital horn of the lateral ventricle was identified in 14 hemispheres (53%) at the level of the first section; and in only one specimen at the level of the second section. The anatomy of the occipital horn was consistent in all of the specimen: half moon shaped, in such way that the medial wall corresponded to the calcar avis and laterally formed by a convex wall, composed of tapetum fibers. There were no observed floor nor presence of collateral eminence or bulb of the corpus calosum (Fig 3). The average measurement from the end of the occipital horn to the splenium was 18 mm, varying from 15 to 32 mm.

DISCUSSION

There are a lot of situations when neurosurgeons need to work in the occipital lobe region, not only for direct intervention of primary lesions, but also for approach to deeper structures underlying the lobe^{12,13,16}. Technology already offers modern intra-operative localization tools - such as neuronavega-

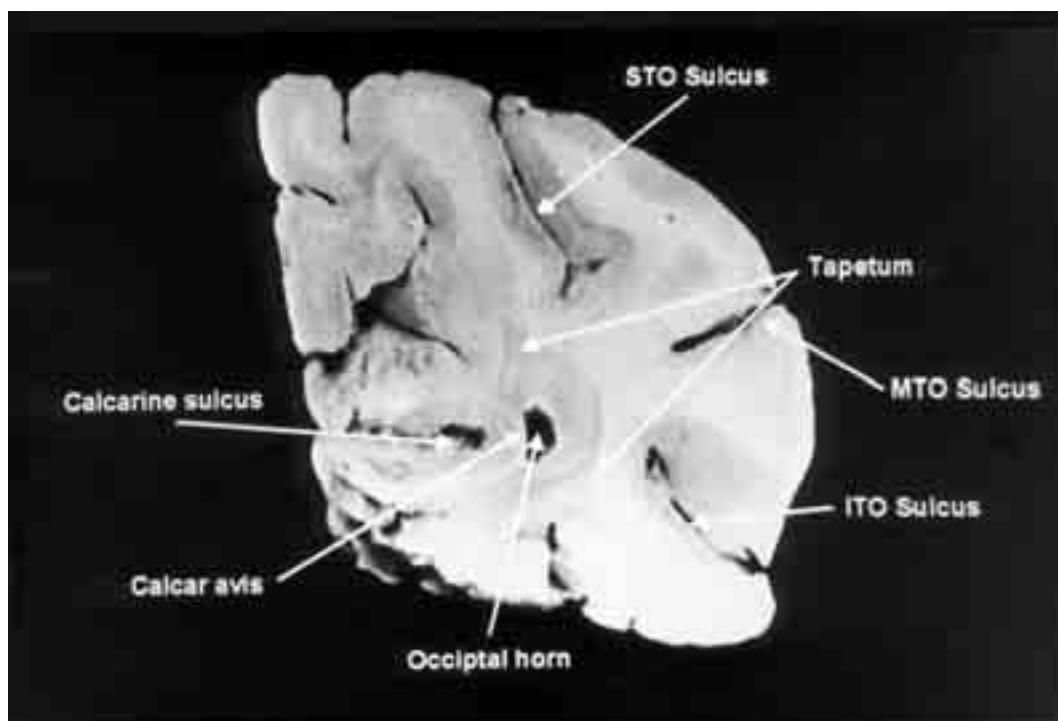


Fig 3. Coronal section at the level of the emergence of the parieto-occipital sulcus at the calcarine sulcus. ITO: inferior transverse occipital; MTO: medium transverse occipital STO: superior transverse occipital.

tion – but the knowledge of anatomy itself is the greatest ally of the surgeon for the planning and execution of the operative act. Differently from other regions of the brain, whose anatomy has already been meticulously detailed⁶, there exist controversies about the occipital region, those of which occasionally can hinder the surgical approaches to this lobe⁴.

The calcarine sulcus is the most important anatomical reference of the posterior interhemispheric fissure region⁸. The data obtained from the present study showed that it invariably appears from the parahippocampal gyrus and it is a sulcus with a few number of side branches. This information can facilitate its identification in surgeries of this area. The measured distances from the medial surface permit the configuration of an anatomical map of this region, having as landmarks the splenium, the calcarine sulcus and the PO sulcus. These results were compared with some measurements done by Ono et al.⁶. These authors, in the work about the sulci of the encephalon, also found similar measurements to the calcarine and PO sulci. The results were very similar: as an example, the distance of the end of the calcarine sulcus to the splenium - 58 mm in both works; or the extension of the PO sulcus - 34 mm in the work by Ono et al.⁶ and 35 mm in the present paper.

The results, in relation the lateral surface of the lobe, brought interesting information. Different to what is quoted in most texts of neuroanatomy^{5-7,10,17}, the occipital lobe has a pattern of sulci with a tendency to repeat in the examined specimen. Transverse sulci were identified in 92% of the hemispheres, most of them found in the same location. The longitudinal sulci were less frequent, but were observed in 62% of the cases. So, this data show that the lobe presents a defined anatomy and this information can be useful to the surgeon who approaches this area. The inferior transverse occipital was the most frequently sulcus identified, being complete in most of the specimen. So, it could be used as an anatomical landmark for surgeries to the lateral surface of the occipital region. The superior transverse sulcus was observed in only 62% of the hemispheres, and was interrupted in most of them, decreasing its value as a surgical reference. Oka et al.¹⁸ described the lateral surface as a region in which there is just one marked sulcus - labeled Lateral Occipital - and divided into two gyri - inferior and superior occipital. The present paper shows that the transverse sulci of the lateral surface delineate three gyri, that can be labeled superior, middle and inferior occipital.

The preoccipital notch is an anatomical structure poorly defined by specialized neuroanatomy literature^{5,6,17,19}. Most of the texts quote this structure as posterior boundary of the temporal lobe or the anterior limit of the occipital lobe^{5,10,19}, most commonly located 50 mm anteriorly to the occipital pole⁷. In all of the specimen of the present study, the preoccipital notch joined the posterior portion of the inferior temporal gyrus to the most anterior portion of the inferior occipital gyrus (localized inferiorly to the inferior transverse occipital sulcus). Its location was quite variable, and it was average positioned 44 mm from the occipital pole. Also, the average distance between the occipital pole and the emergence of the PO sulcus was 35 mm. The traditional limits to occipital lobectomies is the resection of 35 mm left and 70 mm to the right, from the occipital pole¹⁶. According to the identified parameters in this study, resection of the right occipital lobe utilizing the traditional criteria includes portions of the parietal lobe (in some cases it may be desired, depending on the extension of the lesion).

Timurkaynak et al. in their paper about the anatomy of the lateral ventricles, described the occipital horn as a structure with a floor, a medial and a lateral wall¹¹. The present study shows that, at the level of the occipital lobe, the occipital horn has already an different anatomy. In the specimens where it was presented, all of them showed a half moon shaped cavity and the colateral eminence was not observed forming its wall. It was also observed that just in half of the cases there was ventricular cavity at the level of the anterior boundary of the lobe. As such, the surgeon should not expect to find the occipital horn in all performed occipital lobectomies. Besides this, the occipital horn tends to have its end anteriorly to the level of the emergence of the PO sulcus. This information can be useful when working in the posterior interhemispheric fissure: if the surgeon penetrates the ventricle, he/she should consider being located at the precuneus, close to the atrium (obviously, preoperative radiological studies could assist to confirm the posterior extension of the ventricle).

In conclusion, the occipital lobe is a region of the brain that presents anatomical parameters that tend to repeat themselves in different examined sections. This information can be useful for the surgical planning when approaching this area of the encephalon.

Acknowledgments - The author thanks to Mr. Dinaldo de Lima Leite for the assistance in the preparation the specimen.

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