OBJECTIVE: To describe the surgical anatomy of the anterior, middle, and posterior portions of the medial temporal region and to present an anatomic-based classification of the approaches to this area.

METHODS: Twenty formalin-fixed, adult cadaveric specimens were studied. Ten brains provided measurements to compare different surgical strategies. Approaches were demonstrated using 10 silicon-injected cadaveric heads. Surgical cases were used to illustrate the results by the different approaches. Transverse lines at the level of the inferior choroidal point and quadrigeminal plate were used to divide the medial temporal region into anterior, middle, and posterior portions. Surgical approaches to the medial temporal region were classified into four groups: superior, lateral, basal, and medial, based on the surface of the lobe through which the approach was directed. The approaches through the medial group were subdivided further into an anterior approach, the transsylvian transcisternal approach, and two posterior approaches, the occipital interhemispheric and supracerebellar transtentorial approaches.

RESULTS: The anterior portion of the medial temporal region can be reached through the superior, lateral, and basal surfaces of the lobe and the anterior variant of the approach through the medial surface. The posterior group of approaches directed through the medial surface are useful for lesions located in the posterior portion. The middle part of the medial temporal region is the most challenging area to expose, where the approach must be tailored according to the nature of the lesion and its extension to other medial temporal areas.

CONCLUSION: Each approach to medial temporal lesions has technical or functional drawbacks that should be considered when selecting a surgical treatment for a given patient. Dividing the medial temporal region into smaller areas allows for a more precise analysis, not only of the expected anatomic relationships, but also of the possible choices for the safe resection of the lesion. The systematization used here also provides the basis for selection of a combination of approaches.

KEY WORDS: Medial temporal region, Microsurgical anatomy, Surgical approaches, Temporal lobe

The medial temporal region is the site of the most complex cortical anatomy. It is hidden deep within the remainder of the temporal lobe and ventricular system in the margin of the basal cisterns and is surrounded by vascular and neural elements that, unless required for treatment, must be preserved during surgery. Selecting and completing a surgical approach to the medial temporal region remains a challenge because of this anatomic complexity and deep location. There are many articles focusing on the anatomy, physiology, and surgical approaches to the medial temporal region (1, 2, 4, 7–11, 13–28, 30, 33, 34, 36–38, 40–42, 45–48, 52, 53). This study had three goals: to examine the surgical approaches to the area, to divide the approaches into groups based on their anatomic characteristics, and to review the advantages and disadvantages of the approaches in relation to the part of the medial temporal region to be accessed.

MATERIALS AND METHODS

Ten adult, formalin-fixed, cadaveric heads and 10 brains were studied. Coronal cuts, at
the level of the apex of uncus and inferior choroidal point, were performed in the 10 brains and distances between the temporal lobe surface and temporal horn in each approach were measured. Ten silicon-injected heads, dissected using the magnification of the surgical microscope (×3–40; Carl Zeiss, Inc., Thornwood, NY), were used to demonstrate the surgical approaches. Clinical examples of selected approaches are presented.

RESULTS

The surgical approaches to the medial temporal region, based on the temporal surface, through which the approach is directed, are divided into four groups: superior, lateral, basal, and medial. The superior group includes only the transsylvian-transinsular approach. The lateral group includes the approaches through the sulci and gyri on the lateral surface of the temporal lobe and anterior temporal lobectomy with amygdalohippocampectomy. The basal group is comprised of the approach through the occipito-temporal, collateral, or rhinal sulci or through the fusiform and parahippocampal gyri. The medial group is subdivided in an anterior variant, the transsylvian transcisternal approach, and posterior variants, the occipito-interhemispheric and supracerbeellar tentorial approaches.

FIGURE 1. Dissection photographs. A, the relationships of the temporal lobe and horn, cranial sutures, and cortical surfaces of the right side. The coronal, sagittal, squamosal, and lambdoid sutures and the superior temporal line have been preserved and the dura has been opened. The pteron is located at the lateral margin of the sphenoid ridge near the junction of the coronal, squamosal, and frontosphenoid sutures and the lateral end of the greater sphenoid wing and stem of the sylvian fissure. The squamosal suture follows the anterior part of the posterior limb of the sphenoid fissure before turning downward, at the level of the postcentral and supramarginal gyri, to cross the junction of the middle and posterior third of the temporal lobe. The pole of the temporal pole fits into the cupped inner surface of the greater wing of the sphenoid bone. Most of the lateral surface of the temporal lobe is positioned deep to the squamous part of the temporal bone; however, the posterior part of the lateral surface extends beyond the posterior limit of the squamous suture, deep to the parietal bone. The basal surface of the temporal lobe sits on the floor of the middle fossa and is positioned at the level of the upper edge of the zygomatic arch. B, the anterior view of a coronal section, at the level of the sylvian fissure on the right side and the sphenoid ridge in the left side. The pole of the temporal lobe extends forward under the sphenoid ridge and below the sylvian fissure. The inferolateral edge of the temporal lobe is positioned at the lateral edge of the floor of the middle fossa at the level of the zygomatic arch. C, the lateral view of the right temporal lobe. The temporal convexity is composed of the superior, middle, and inferior temporal gyri, which are divided by the superior and inferior temporal sulci. The inferior temporal gyrus folds around the lower margin of the hemisphere onto the lateral part of the basal hemispheric surface. The supramarginal gyrus wraps around the upturned posterior end of the sylvian fissure. D, that the frontal and parietal lobes, above the level of the sylvian fissure, have been removed. The upper lip of the calcineur sulcus, formed by the cuneus, has been removed to expose the lingula that forms the lower bank of the calcineur sulcus. The temporal horn and hippocampus lie deep to the middle temporal gyri, which has been removed. The atrium lies deep to the supramarginal gyrus. The central sulcus ascends between the precentral and postcentral gyri. There is commonly a gyrus bridge (red arrow) connecting the precentral and postcentral gyri below the lower end of the central sulcus, in which case the central sulcus does not open directly into the sylvian fissure. The calcar avis is the prominence in the lower part of the medial atrial wall overlying the deep end of the calcarine sulcus. E, another right cerebral hemisphere with the frontal, parietal, and lateral part of the temporal lobes removed to expose the temporal horn. The choroid plexus, which attaches along the choroidal fissure, has been preserved. The inferior choroidal point, the anterior end of the plexal attachment in the temporal horn, is positioned behind the hippocampal head. The collateral eminence, located on the lateral side of the hippocampus, overlies the deep end of the collateral sulcus. F, that the choroid plexus has been removed in another specimen to expose the choroidal fissure located between the thalamus and fornix. The amygdala forms the anterior wall of the frontal horn. The uncal recess extends medially between the hippocampal head and the amygdala. The uncal recess is positioned lateral to the apex of the uncus. The upper surface of the parahippocampal gyrus is exposed medial to the fimbria. G, the enlarged view of another specimen. The choroidal fissure extends from the foramen of Monro to the inferior choroidal point located behind the head of the hippocampus. The choroid plexus, which attaches along the choroidal fissure, has been removed. The lower edge of the choroidal fissure in the temporal horn is formed by the fimbria of the fornix and the upper edge is formed by the thalamus. Opening the fissure between the lower surface of the thalamus and the fimbria of the fornix exposes the ambient cistern. The lateral geniculate body is exposed at the lower margin of the thalamus in the upper wall of the ambient cistern. The anterior wall of the temporal horn is formed by the amygdala, which tilts backward above, but is separated from the hippocampal head by the temporal horn. The uncal recess extends medially between the head of the hippocampus and amygdala. H, the superior view of a transverse section through the right temporal horn. The hippocampus and collateral eminence form the floor of the temporal horn. The amygdala occupies the anterior segment and the head of the hippocampus occupies the posterior segment of the uncus. The apex of the uncus is directed medially at the level of the uncal recess. The fimbria arises on the surface of the hippocampus. The upper surface of the parahippocampal gyrus is exposed medial to the fimbria. The collateral eminence overlies the deep end of the collateral sulcus, which extends along the basal surface on the lateral side of the parahippocampal gyrus. The hippocampus meets the calcar avis at the junction of the atrium and temporal horn. A.Ch.A., anterior choroidal artery; Ant., anterior; Calc., calcar, calcarine; Cap., capsule; Caud., caudate; Cent., central; Chor., choroid, choroidal; Coll., collateral; Emin., eminence; Fiss., fissure; Frontal, frontal; For., foramen; Gen., geniculate; Hippo., hippocampal, hippocampus; Inf., inferior; Int., internal; Lat., lateral; Lent., lentiform; M., muscle; M.C.A., middle cerebral artery; Mid., middle; Nucl., nucleus; Par. Occip., parieto-occipital; Parahippo., parahippocampal; Plex., plexus; Postcent., postcentral; Precent., precentral; Seg., segment; Sphen., sphenoid; Squam., squamosal; Sup., Superior; Supramarg., supramarginal; Temp., temporal; Zygo., zygomatic.
MEDIAL TEMPORAL REGION APPROACHES

A
Sup. Temp. Line
Squar. Suture
Sup. Temp. Lobe
Temp. Pole
Coronal Suture
B
Sylvian Fiss.
Sphen. Ridge
Temp. M.
Squar. Suture
Zyg. Arch
C
Postcent. Gyrus
Supramarg. Gyrus
Temp. Sulcus
Inf. Temp. Gyrus
Inf. Temp. Sulcus
Zyg. Arch
D
Par. Occip. Sulcus
Front. Horn
Calc. Avis
Calc. Sulcus
Atrium
Sylvian Fiss.
Chor. Plex.
Chor. Fiss.
E
Postcent. Gyrus
Supr. Temp. Gyrus
Mid. Temp. Gyrus
Temp. Lobe
Calc. Avis
Calc. Sulcus
Atrium
Parahippoc. Gyrus
Fimbria
Thalamus
Inf. Chor. Point
Ant. Ch. A.
For. Monro
Lent. Nucl.
Coll. Emin.
F
Thalamus
Crus Fornix
Pulvinar
Parahippoc. Gyrus
Chor. Fiss.
Inf. Chor. Point
Ant. Seg.
M.C.A.
Amygdala
Hippoc. Head
G
Hippoc. Body
Inf. Chor. Point
Chor. Fiss.
Coll. Emin.
Amygdala
Hippoc. Head
Lat. Gen. Body
Hippoc. Head
Calc. Avis
H
Parahippoc. Gyrus
Hippoc. Body
Hippoc. Head
Hippoc. Body
Uncal Recess
Fimbria
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Anatomic Relationships

Craniotemporal Aspects

The temporal lobe is located on the lower part of the hemisphere and rests on the floor of the middle fossa and the tentorium (Fig. 1). The lateral surface of the temporal lobe forms the lower portion of the lateral convexity. It sits medial to the temporal fossa, the site of the temporalis muscle, and below the superior temporal line along which the muscle attaches. All of the middle and anterior parts of the lateral surface sit within the area outlined by the squamosal suture, deep to the squamosal part of the temporal bone, but its posterior part extends back beyond the squamosal part of the temporal bone into the area deep to the parietal bone (Fig. 1A). The temporal horn is positioned approximately 2 cm above the zygomatic arch, deep to the squamosal part of the temporal bone and the middle temporal gyrus. The inferolateral border of the temporal lobe, which marks the transition be-

FIGURE 2. Dissection photographs showing cortical relationships. A, lateral view of the right cerebral hemisphere. The lateral temporal surface is divided by the superior and inferior temporal sulci into the superior, middle, and inferior temporal gyri. Both the temporal gyri and sulci are parallel to the sylvian fissure. The sylvian fissure and central sulcus are the most important landmarks on the lateral surface of the brain. The sylvian fissure extends backward and turns up into the supramarginal gyrus at its posterior end. The inferior frontal gyrus is composed of the pars orbitalis, pars triangularis, and pars opercularis. The angular gyrus wraps around the upturned posterior end of the superior temporal sulcus. The temporal lobe is separated from the parietal lobe by the sylvian fissure and the extended sylvian line, which extends backward along the long axis of the sylvian fissure; from the occipital lobe on the lateral convexity, by the inferior part of the lateral parietotemporal line, which runs from the impression of the parieto-occipital sulcus on the superior margin of the hemisphere to the preoccipital notch; from the occipital lobe on the lower surface by the basal parietotemporal line, which extends from the junction of the calcine and parieto-occipital sulcus to the preoccipital notch; and from the insula, by the inferior portion of the limiting sulcus of the insula. B, opercular lips of the sylvian fissure have been retracted to expose the insula and superior surface of the temporal lobe. The insula has a triangular shape with its apex directed anterior and inferior toward the limen insulae. The insula is incised and separated from the frontal, parietal, and temporal opercula by a shallow limiting sulcus. The lower part of the limiting sulcus that borders the temporal lobe is referred to as the inferior limiting sulcus. The central sulcus of the insula separates the short gyriform anteriorly from the long gyri posteriorly. The superior surface of the temporal lobe has two parts: the posteriorly placed planum polare, formed by the transverse temporal gyri, the most anterior of which is Heschl’s gyrus, and the planum temporale, which forms the floor of the anterior part of the sylvian fissure. The temporal lobe is connected superiorly to the insula by the temporal stem and anteriorly to the basal frontal lobe by the limen insulae. C, basal view of the right temporal lobe. The basal temporal surface is traversed longitudinally by the occipitotemporal, collateral, and rhinal sulci that divide it from lateral to medial into the lower surface of the inferior temporal gyrus and the occipitotemporal (fusiform) and parahippocampal gyri. The anterior end of the parahippocampal gyrus deviates medially to form the uncus. The rhinal sulcus is located lateral to the uncus. The collateral sulcus may or may not be continuous anteriorly with the rhinal sulcus. The uncus has an anterior segment, an apex, and a posterior segment. The medial part of the uncus usually projects medial to and is often grooved (red arrow) by the tentorial edge. D, medial surface of the right cerebral hemisphere. The medial surface of the temporal lobe is the most complex of the medial cortical areas. It is composed of three longitudinal strips of neural tissue, one located above the other. The most inferior strip is formed by the parahippocampal gyrus, the middle strip by the dentate gyrus, and the superior strip by the fimbria of the fornix. The choroidal fissure in the temporal horn is located between the fimbria and the lower surface of the thalamus. The parahippocampal gyrus forms most of the medial surface of the temporal lobe. Anteriorly, the parahippocampal gyrus deviates medially to form the uncus. Posteriorly, it is intersected by the calcarine sulcus, which divides the posterior portion of the parahippocampal gyrus into an upper part that is continuous with the isthmus of the cingulate gyrus and a lower part that is continuous with the lingula. E, enlarged view of D. The parahippocampal gyrus has been retracted to expose the dentate gyrus. The parahippocampal and dentate gyri are separated by the hippocampal sulcus, and the dentate gyrus and fimbria are separated by the fimbriodentate sulcus. In the temporal horn, the choroidal fissure is located between thalamus and fimbria of fornix. The medial temporal region is divided into three parts: anterior, middle, and posterior. The anterior part (green brackets) extends posteriorly from the anterior end of the rhinal sulcus and uncus to a transverse line at the level of the inferior choroidal point. The middle part (red brackets) extends posteriorly from the inferior choroidal point to a transverse line passing at the level of the quadrigeminal plate. The posterior part (blue brackets) extends from the quadrigeminal plate to the level of the basal parietotemporal line, which connects the preoccipital notch to the lower end of the parieto-occipital sulcus. F, superior view of the right temporal lobe with the anterior, middle, and posterior part bracketed as in E. The upper surface of the temporal lobe forms the floor of the sylvian fissure and presents two distinct parts: the planum polare anteriorly and the planum temporale posteriorly. The planum polare is free of gyri, and its lateral edge is formed by the superior temporal gyrus. The planum temporale is formed by the transverse temporal gyri. The inferior choroidal point, the lower end of the choroidal fissure, is located just behind the uncus and head of the hippocampus. The amygdala, located predominantly within the boundaries of the uncus, forms most of the anterior segment of the uncus and the anterior wall of the temporal horn. Superiorly, the amygdala blends into the globus pallidus without any clear demarcation. The hippocampus sits in the floor of the temporal horn. The head of the hippocampus is directed anteriorly and mediately and is buried in the upper half of the posterior segment of the uncus. G, coronal section of a right temporal lobe at the level of the apex of the uncus (insert). The temporal stem, the layer of white and gray matter that connects the temporal lobe to the lower insula, is positioned above the temporal horn. H, coronal section of a right temporal lobe at the level of the inferior choroidal point (insert), which is positioned at the junction of the anterior and middle portions of the medial temporal lobe. The inferior choroidal point is located at the posterior edge of the uncus and at the anterior end of the choroidal plexus and choroidal fissure in the temporal horn. Ang., angular; Ant., anterior; Calc., calcineus; Cent., central; Chor., choroidal or choroid; Coll., collateral; Dent., dentate; Emin., eminence; Fiss., fissure; Hippo., hippocampus; Inf., inferior; Ins., insular; Lim., limiting; Mid., middle; Occip., occipital; Operc., opercularis; Orb., orbitalis; Par. Occip., parieto-occipital; Parahippo., parahippocampal; Plex., plexus; Post., posterior; Postcent., postcentral; Precent., precentral; Seg., segment; Sup., superior; Supramarg., supramarginal; Temp., temporal; Triang., triangularis.
between the lateral and basal surfaces, is positioned at the level of the superior border of the zygomatic arch and supramastoid crest (Fig. 1, A and B). The shape of the floor of the middle fossa changes from being a spoon-shaped concavity anteriorly to flat with a gradual superior inclination from lateral to medial in its posterior portion. The position of the anterior tip of the temporal horn, as viewed through the basal surface, approximates a coronal line that passes at the level of the foramen ovale laterally and the entrance of the oculomotor nerve into the roof of the cavernous sinus medially. The concavity of the middle fossa adds to the difficulty in exposing the basal surface of the temporal lobe and, if not managed appropriately, may result in retraction injuries to the lobe.

**Temporal Lobe Anatomy**

The temporal lobe is separated from the frontal lobe by the stem and posterior ramus of the sylvian fissure; from the parietal lobe by the posterior ramus of the sylvian fissure and the extended sylvian line, which extends backwards along the long axis of the sylvian fissure; from the occipital lobe laterally by the inferior part of the lateral parietotemporal line, which runs from the impression of the parieto-occipital sulcus on the lateral surface to the preoccipital notch, and on the lower surface by the basal parietotemporal line, which extends from the junction of the calcarine and parieto-occipital sulcus to the preoccipital notch; and from insula by the inferior portion of the limiting sulcus of the insula (Fig. 2). The temporal lobe has four surfaces: medial, superior, lateral, and basal, each of which is the site of one of one or more approaches to the medial temporal region. The four surfaces meet anteriorly at the rounded temporal pole.

**Medial Surface**

The medial surface of the temporal lobe is the most complex cortical area (Figs. 2–4) (12). It is formed predominantly by the rounded medial surfaces of the parahippocampal gyrus and uncus and is limited laterally by the collateral and rhinal sulci. The medial surface is composed of three longitudinal strips of neural tissue, one located above the other, which are interlocked with the hippocampal formation and amygdala. The...
most inferior strip is formed by the rounded medial edge of the parahippocampal gyrus, the site of the subicular zones; the middle strip is formed by the dentate gyrus, a narrow serrated strip of gray matter located on the medial surface of the hippocampal formation; and the superior strip is formed by the fimbria of the fornix, a white band formed by the fibers emanating from the hippocampal formation and directed posteriorly into the crus of the fornix. The parahippocampal and dentate gyri are separated by the hippocampal sulcus, and the dentate gyrus and the fimbria are separated by the fimbria-dentate sulcus. The amygdala and hippocampal formation lie just beneath and are so intimately related to the mesial temporal cortex that they are considered in this section.

The parahippocampal gyrus deviates medially at the site of the uncus, which commonly projects above the tentorial edge and is separated from the remainder of the basal surface by the rhinal sulcus. The uncus, the medially projecting anterior part of the parahippocampal gyrus, when viewed from above or below has an angular shape with anterior and posterior segments that meet at a medially directed apex. The anterior segment of the uncus faces anteromedially and the posterior segment faces posteromedially. The anterior segment has an undivided medial surface, but the posterior segment is divided into upper and lower parts by the uncal notch, a short sulcus that extends from posteriorly into the medial aspect of the posterior segment (Figs. 2E, 3B, and 4B). The medial face of the anterior segment faces the proximal part of the sylvian and carotid cisterns and the internal carotid and proximal middle cerebral arteries. The posterior segment faces the cerebral peduncle and, with the peduncle, forms the lateral and medial walls of the crural cistern, through which the posterior cerebral, anterior choroidal, and medial posterior choroidal arteries pass. The optic tract passes above the medial edge of the posterior segment in the roof of the temporal horn. Anterior to the hippocampus extends backward along the medial part of the temporal horn. Superiorly, the amygdala blends into the claustrum and globus pallidus without any clear demarcation (Fig. 3D). The upper posterior portion of the amygdala tilts back above the hippocampal head and the uncal recess at the anterior edge of the roof of the temporal horn. In coronal cross-sections, the optic tract sits medial to the junction of the amygdala and globus pallidus (Fig. 3D).

The hippocampus, which blends into and forms the upper part of the posterior uncal segment, is a curved elevation, approximately 5 cm long, in the medial part of the entire length of the floor of the temporal horn (Fig. 1). It has the dentate gyrus along its medial edge and a curved collection of gray matter in its interior that is referred to as Ammon’s horn. It sits above and is continuous below with the rounded medial surface of the parahippocampal gyrus referred to as the subicular surface. Ammon’s horn is characterized in transverse sections of the hippocampus by its reversed c, or comma shape, associated with its tightly packed pyramidal cell layer.

The hippocampus is divided into three parts: head, body, and tail (Fig. 1). The head of the hippocampus, the anterior and the largest part, is directed anteriorly and medially and forms the upper part of the posterior uncal segment. Its upper surface is the site of three or four shallow hippocampal indentations, making it resemble a feline paw and giving it the name pes hippocampus. The initial segment of the fimbria and the choroidal fissure are located at the posterior edge of the hippocampal head. Superiorly, the anterior part of the head of the hippocampus faces the posterior portion of the amygdala that is tilted backward above the hippocampal head at the anterior edge of the roof of the temporal horn. Anterior to the hippocampal head is the uncal recess, a cleft located between the head of the hippocampus and the amygdala. The body of the hippocampus extends backward along the medial part of the floor of the temporal horn, narrowing into the tail that disappears as a ventricular structure at the anterior edge of the medial wall of the atrium. The fimbria of the fornix arises on the ventricular surface of the hippocampus behind the head and the lower end of the choroidal fissure.

The temporal horn extends forward from the atrium below the pulvinar into the medial part of the temporal lobe
FIGURE 4. Dissection photographs showing the basal surface of the temporal lobe. A, collateral sulcus separates the parahippocampal and occipitotemporal gyri and extends backward onto the occipital lobe. The parahippocampal gyrus is broken up into several segments by sulci crossing it from medial to lateral. The occipitotemporal gyrus, which form the middle strip along the long axis of the basal surfaces, are discontinuous, as are the inferior temporal gyri that fold from the convexity around the lower margin of the hemisphere. The rhinal sulci that extend along the lateral margin of the uncus are not in continuity with the collateral sulci, as exists in some hemisphere and as shown in B, B, basal surface of another left temporal lobe. The uncus has an anterior segment that faces forward toward the carotid cistern and entrance into the sylvian cistern and a posterior segment that faces posteriorly toward the cerebral peduncle and crural cistern. The apex between the anterior and posterior segment is located lateral to the oculomotor nerve. The posterior segment of the uncus faces the cerebral peduncle and crural cistern. The ambient cistern is located behind the uncus between the lateral side of the midbrain and the parahippocampal gyrus. The rhinal sulcus courses along the lateral edge of the uncus and is continuous with the collateral sulcus. The posterior segment of the uncus is divided into an upper and lower part by the uncal notch. C, part of the posterior segment of the uncus below the uncal notch and the medial part of the parahippocampal gyrus have been removed to expose the lower surface of the upper half of the posterior segment that blends posteriorly into the beaded dentate gyrus. The fimbria of the fornix is exposed above the dentate gyrus. The head of the hippocampus folds into the upper part of the posterior segment of the uncus. The choroidal fissure, located between the thalamus and fimbria, extends along the lateral edge of the lateral geniculate body. D, hippocampus and dentate gyrus have been removed while preserving the fimbria and choroid plexus. The choroid plexus is attached on one side of the choroidal fissure to the fimbria and on the opposite side to the lower margin of the thalamus. The amygdala forms the anterior wall of the temporal horn and fills most of the anterior segment of the uncus. The inferior choroidal point, the lower end of the choroidal fissure and the choroidal plecxes, is located behind the posterior segment of the uncus. E, fimbria and choroid plexuses have been removed to expose the roof of the temporal horn. The lower part of the anterior uncal segment has been removed to expose the upper part of the amygdala. A small portion of the posterior uncal segment setting below the optic tract has been preserved. The inferior choroidal point, the most anterior attachment of the choroidal plecxes in the temporal horn and the lower end of the choroidal fissure, is located behind the head of the hippocampus, anterior to the lateral geniculate body, and at the posterior edge of the cerebral peduncle. A thin layer of tapetal fibers from the corpus callosum forms the roof and lateral wall of the temporal horn and atrium. The thin layer of tapetal fibers is all that separates the roof of the temporal horn from the optic radiations. F, this layer of tapetal fibers in the roof and lateral wall of the temporal horn has been removed to expose the fibers of the optic radiation arising from the lateral geniculate body and passing across the roof of the temporal horn and around the lateral wall of the temporal horn and atrium. Meyer’s loop of the optic radiations extends forward to the anterior tip of the roof of the temporal horn. The cuneus forms the upper bank and the lingula forms the lower bank of the calcarine sulcus. Ant., anterior; Calc., calcareous; Chor., choroid, choroidal; CN, cranial nerve; Coll., collateral; Dent., dentate; Gen., geniculate; Inf., inferior; Lat., lateral; Mam., mammillary; Occip., occipital; Parahippo., parahippocampal; Perf., perforated; Plex., plexus; Post., posterior; Rad., radiations; Seg., segment; Subst., substance; Temp., temporal; Tr., tract.
to the anterior edge of the hippocampal head and just behind the amygdala (Figs. 1, 4, and 5). The temporal horn ends approximately 2.5 cm from the temporal pole. The floor of the temporal horn is formed medially by the hippocampus and laterally by the collateral eminence, the prominence overlying the collateral sulcus. The medial part of the roof is formed by the inferior surface of the thalamus and the tail of the caudate nucleus, which are separated by the striothalamic sulcus. The lateral part of the roof is formed by the tapetum of the corpus callosum, which also sweeps inferiorly to form the lateral wall of the temporal horn. The tapetum separates the temporal horn from the optic radiation. The only structure in the medial wall is formed by the tapetum of the corpus callosum, which also forms the striothalamic sulcus. The lateral part of the roof is formed by the choroidal fissure, situated between the inferolateral part of the thalamus and the fornix. The inferior choroidal point, at the lower end of the choroidal fissure, is located just behind the head of the hippocampus and immediately lateral to the lateral geniculate body.

**FIGURE 5.** Dissection photographs. A, superior view of the right temporal lobe and horn with the frontal and parietal lobes and the thalamus removed. The medial temporal region can be divided in three parts: anterior, middle, and posterior. The anterior portion of the medial temporal region is limited anteriorly by the anterior end of the rhinal sulcus and posteriorly by a transverse line at the level of inferior orbital fissure, located at the posterior edges of the uncus and hippocampal head. The junction of the middle and posterior parts is located at the level of the quadrigeminal plate. The posterior part of the superior surface is positioned at the level of the basal parietotemporal line, which connects the pre-occipital notch to the inferior end of the paramedian sulcus. The anterior part includes both the anterior and posterior segments of the uncus. The anterior segment of the uncus faces the carotid and sylvian cisterns and the posterior segment faces the carotid cistern. The middle portion is formed by the parahippocampal and dentate gyrus and forms the lateral wall of the ambient cistern. The posterior portion is formed by the most posterior portion of the parahippocampal gyrus, the isthmus of cingulate gyrus, and the anterior part of the lingula and forms the lateral wall of the quadrigeminal cistern. The anterior segment of the uncus contains the amygdala. The apex of the uncus is located medial to the uncus recess of the temporal horn and lateral to the oculomotor nerve. The uncus recess extends medially between the amygdala and the head of the hippocampus. The head of the hippocampus sits in the upper part of the middle temporal region. The middle part of the medial temporal region is composed, from below to above, by the parahippocampal gyrus, dentate gyrus, fimbria, choroid plexus, body of the hippocampus, and the collateral eminence. The posterior part includes the choroid plexus, choroidal fissure, tail of the hippocampus, and the collateral trigone, in addition to the cortical surface facing the quadrigeminal cistern. The carotid, ambient, and quadrigeminal cisterns are located on the medial side of the temporal lobe. B, upper part of the right cerebral hemisphere has been removed to expose the temporal horn, atrium, and the basal cisterns. The internal carotid and middle cerebral arteries cross the anterior segment of the uncus. The M1 segment of the middle cerebral artery courses on the upper surface of the temporal pole, and the M2 segment crosses the insula just above and lateral to the temporal horn. The posterior cerebral arteries pass posteriorly in the cerebral and ambient cisterns to reach the quadrigeminal cistern. The P2A segment of the posterior cerebral artery courses medial to the uncus in the crural cistern, the P2P courses in the ambient cistern, and the P3 courses in the quadrigeminal cistern. The anterior choroidal artery passes around the upper part of the uncus to enter the temporal horn and choroid plexus at the anterior choroidal point. The sylvian point is located where the most posterior branch of the M2 segment turns away from the insular surface toward the lateral convexity. The upper surface of the temporal lobe forms the floor of the sylvian fissure and presents two distinct parts: the planum polare anteriorly and the planum temporale posteriorly. The planum polare is free of gyri and its lateral edge is formed by the superior temporal gyrus. The planum temporale is formed by the transverse temporal gyrus. C, inferior view of the superficial surface of the temporal horn. The temporal lobe has been removed to expose the upper surface of the planum temporale and the adjacent perisylvian cortex. Red pins face the medial cortex, yellow pins face the lateral cortex, green pins face the ambient cortex, and gray pins face the quadrigeminal cortex. D-F, stepwise dissection of another medial temporal lobe demonstrating the relationships of the anterior, middle, and posterior portions of the medial temporal region. D, structures below the roof of the right temporal horn have been removed to expose the course of the posterior cerebral artery through the cisterns on the medial side of the temporal horn. E, right posterior cerebral artery has been removed to expose the anterior choroidal artery. The inferior choroidal point marks the lower end of the choroidal fissure. The anterior choroidal artery enters and the inferior ventricular vein exits the temporal horn at the inferior choroidal point. The inferior choroidal point is located at the posterior edge of the posterior segment of the uncus, and the crural cistern is located at the junction of the anterior and middle parts of the medial temporal region. F, right anterior choroidal artery has been removed to expose the most superior portion of the crural and ambient cisterns and the basal vein. Both the inferior ventricular and inferior choroidal veins empty into the basal vein at the inferior choroidal point. The left posterior cerebral artery has been removed to expose the anterior choroidal artery. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ant., anterior; Car., carotid; Chor., choroid, Chist., cistern; CN, cranial nerve; Dent., dentate; Gen., geniculate; Hippo., hippocampal; Inf., inferior; Lat., lateral; M1, M2, M3, segments of the middle cerebral artery; Med., medial; Parahippo., parahippocampal; P1, segment of the posterior cerebral artery; P2A, anterior portion of the P2 segment of the posterior cerebral artery; P2P, posterior portion of the P2 segment of the posterior cerebral artery; P.C.O.A., posterior communicating artery; Flex., plexus; Post., posterior; Quad., quadrigeminal; Seg., segment; Temp., temporal, temporale; Tent., tentorial; V., vein; Vent., ventricular.
front of Heschl’s gyrus, the medial edge of the planum polare is separated from insula by the inferior portion of the limiting sulcus of the insula, often referred to as the inferior limiting sulcus, an important site in positioning the incision in the transsylvian-transinsular approach. The mean distance from the anterior part of the limiting sulcus to the roof of temporal horn is 9.3 mm at the level of the apex of the uncus and 8.2 mm at the inferior choroidal point. Table 1 shows the range and standard deviation for these measurements. The temporal horn is located 45 degrees medial to the sagittal plane through the anterior part of the limiting sulcus; thus, to reach the temporal horn, the incision must be directed approximately 45 degrees medially from the limiting sulcus toward the midpoint of the lateral wall of the cavernous sinus. Failure to direct the incision medially will result in the incision crossing Meyer’s loop of the optic radiations. We have reviewed the relationship between the inferior insular sulcus and the optic radiations in another article (3, 31).

### Lateral Surface

The lateral temporal surface is divided into three parallel gyri—superior, middle, and inferior temporal—by two sulci, the superior and inferior temporal sulci, all of which parallel the sylvian fissure (Figs. 1 and 2). The anterior portion of all of the sulci and gyri can be used for ventricular entry, although the superior temporal gyrus is infrequently used for this purpose. The superior temporal gyrus lies between the sylvian fissure and the superior temporal sulcus and is continuous around the lip of the fissure with the transverse temporal gyri. The posterior end of the superior temporal gyrus blends upward into the posterior part of the supramarginal gyrus. The angular gyrus, a parietal lobe structure, caps the upturned posterior end of the superior temporal sulcus. The middle temporal gyrus lies between the superior and inferior temporal sulci. The temporal horn and the ambient and the crural cisterns are located deep to the middle temporal gyrus. The inferior temporal gyrus lies below the inferior temporal sulcus and continues around the inferior border of the hemisphere to

### Basal Surface

The basal surface of the temporal lobe is traversed longitudinally by the collateral and rhinal sulci medially and the occipitotemporal sulci laterally, which divide the region from medial to lateral into the parahippocampal and occipitotemporal (fusiform) gyri and the lower surface of the inferior

### TABLE 1. Distance between temporal gyri and sulci and the temporal horn (in millimeters) at the uncal apex and inferior choroidal point

<table>
<thead>
<tr>
<th>Gyrus (surface) or sulcus (deep end)</th>
<th>Uncal apex</th>
<th>Inferior choroidal point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting sulcus of insula</td>
<td>9.3 (7.2–11.0)</td>
<td>8.2 (7.0–9.5)</td>
</tr>
<tr>
<td>Superior temporal sulcus</td>
<td>12.4 (10.4–14.8)</td>
<td>11.2 (9.2–17.5)</td>
</tr>
<tr>
<td>Inferior temporal sulcus</td>
<td>13.1 (10.0–17.9)</td>
<td>14.3 (9.0–20.0)</td>
</tr>
<tr>
<td>Occipitotemporal sulcus</td>
<td>7.9 (4.2–11.8)</td>
<td>6.0 (4.0–8.5)</td>
</tr>
<tr>
<td>Collateral and/or rhinal sulcus</td>
<td>3.9 (2.9–6.0)</td>
<td>6.4 (2.9–11.2)</td>
</tr>
<tr>
<td>Superior temporal gyrus</td>
<td>31.4 (27.0–35.3)</td>
<td>34.2 (29.8–40.1)</td>
</tr>
<tr>
<td>Middle temporal gyrus</td>
<td>26.3 (19.6–31.5)</td>
<td>23.8 (18.6–30.7)</td>
</tr>
<tr>
<td>Inferior temporal gyrus</td>
<td>20.2 (17.2–23.3)</td>
<td>21.9 (19.5–25.3)</td>
</tr>
<tr>
<td>Fusiform gyrus</td>
<td>11.9 (9.5–14.2)</td>
<td>13.6 (11.1–16.1)</td>
</tr>
<tr>
<td>Parahippocampal gyrus (basal surface)</td>
<td>8.5 (6.9–10.7)</td>
<td>14.6 (10.8–17.9)</td>
</tr>
</tbody>
</table>
temporal gyrus (Figs. 2C, 4, and 5). Any of the gyri or sulci can be selected as the site of entry into the temporal horn. The anterior end of the basal surface projects medially to form the uncus without a limiting border between the uncus and parahippocampal gyrus. The basal surface of the parahippocampal gyrus forms the medial part of the inferior surface. It extends backward from the temporal pole to the posterior margin of the corpus callosum. Posteriorly, the part of the parahippocampal gyrus below the splenium of the corpus callosum is intersected by the anterior end of the calcarine sulcus, which divides the posterior portion of the parahippocampal gyrus into an upper part that is continuous above, posteriorly with the isthmus of the cingulate gyrus, and below and posteriorly with the lingual gyrus.

The collateral sulcus, one of the most constant cerebral sulci, courses between the parahippocampal and the occipitotemporal gyri. The collateral sulcus may or may not be continuous anteriorly with the rhinal sulcus, the short sulcus, extending along and marking the lateral edge of the uncus. The collateral sulcus is located below and indents deeply into the basal surface of the temporal horn producing a prominence, the collateral eminence, in the floor of the temporal horn on the lateral side of the hippocampus. The temporal horn can be exposed from below by opening through the deep end of the collateral sulcus.

The temporal horn is located superior to parahippocampal gyrus; thus, the more medial the basal temporal corticectomy, the more vertical the surgical trajectory needs to be to reach the temporal horn (Figs. 4 and 5). The average distance from the deep end of the occipitotemporal sulcus to the temporal horn is 7.9 mm at the level of the apex of uncus and 6.0 mm at the level of the inferior choroidal point (Table 1). The average distance from the fusiform gyrus to the temporal horn is 11.9 mm at the level of the apex of uncus and is 13.6 mm at the inferior choroidal point. The average distance from the depth of the collateral/rhinal sulcus to the temporal horn is 3.9 mm at the level of the apex of uncus and is 6.4 mm at the inferior choroidal point. The average distance from the parahippocampal gyrus to the temporal horn is 8.5 mm at the level of the apex of uncus and is 14.6 mm at the level of the inferior choroidal point.

Subdivision of the Medial Temporal Lobe

De Oliveira et al. (8, 9) and Tedeschi et al. (43) divided the medial temporal region into three parts: anterior, middle, and posterior (Figs. 2, E and F and 5A). The anterior part extends posteriorly from the anterior end of the rhinal sulcus to a transverse line at the level of the inferior choroidal point. The middle part extends posteriorly from the inferior choroidal point to a transverse line passing at the level of the quadrigeminal plate. The posterior part extends from the quadrigeminal plate to the level of the basal parietotemporal line, which connects the preoccipital notch to the lower end of the parieto-occipital fissure.

Each part of the medial temporal region has cisternal and ventricular components (Table 2). The anterior part includes the cisternal surfaces of uncus and the adjacent portion of the parahippocampal gyrus. The anterior portion of the uncus faces the carotid and sylvian cisterns, and the posterior segment faces the cerebral peduncle across the crural cistern. The anterior portion is the site of the amygdala and head of the hippocampus and the uncal recess, located between the amygdala and the hippocampal head. This anterior portion of the temporal horn is located in front of the inferior choroidal point and the attachment of the choroid plexus.

The middle portion of medial temporal region is formed medially by the cisternal surface of the parahippocampal and dentate gyri and fimbria. The ventricular surface of the middle part is formed by the body of hippocampus, the collateral eminence, the choroid plexus, and choroidal fissure. This part is located posterior to the uncus and crural cistern at the level of the ambient cistern. The choroidal fissure in the temporal horn is located behind to the uncus and the inferior choroidal point. The anterior choroidal artery enters the temporal horn and the inferior ventricular vein exits the roof of the ventricle.

<table>
<thead>
<tr>
<th>TABLE 2. Cisternal and ventricular components of the anterior, middle, and posterior parts of the medial temporal region</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cisternal elements</strong></td>
</tr>
<tr>
<td>Anterior part</td>
</tr>
<tr>
<td>Anterior and posterior segments and apex of uncus</td>
</tr>
<tr>
<td>Parahippocampal gyrus (lateral to the uncus)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Middle part</td>
</tr>
<tr>
<td>Parahippocampal gyrus (posterior to the uncus)</td>
</tr>
<tr>
<td>Hippocampal sulcus</td>
</tr>
<tr>
<td>Dentate gyrus</td>
</tr>
<tr>
<td>Fimbriodentate sulcus</td>
</tr>
<tr>
<td>Fimbria</td>
</tr>
<tr>
<td>Posterior part</td>
</tr>
<tr>
<td>Parahippocampal gyrus (posterior portion)</td>
</tr>
<tr>
<td>Isthmus of cingulate gyrus</td>
</tr>
<tr>
<td>Anterior most portion of lingula</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### TABLE 3. Advantages and disadvantages of surgical approaches to medial temporal region by temporal lobe surface through which the approach is directed

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superior surface: transsylvian-transinsular approach</strong></td>
<td>Small working window, which may make it difficult to complete an <em>en bloc</em> resection of hippocampus and adjacent structures.</td>
</tr>
<tr>
<td>Preserves the lateral and basal temporal cortex involved in language and higher cortical function.</td>
<td>Entrance into temporal horn through its roof can cause Meyer’s loop injury.</td>
</tr>
<tr>
<td>Corticotomy along anterior part of the inferior insular sutures can be enlarged by opening forward along the area of the limen insulae.</td>
<td>Opening posteriorly along inferior insular sulcus may damage optic radiations.</td>
</tr>
<tr>
<td>May be combined with the transsylvian transcisternal approach.</td>
<td>Produces lesion of the lateral temporal cortex (significant in the dominant hemisphere).</td>
</tr>
<tr>
<td><strong>Lateral surface: transsulcal or transgyral approaches</strong></td>
<td>May cause injury to optic radiations if entrance into temporal horn is extended posteriorly through its lateral wall.</td>
</tr>
<tr>
<td>Technically less complex.</td>
<td>Significant distance between the lateral surface of temporal lobe and temporal horn.</td>
</tr>
<tr>
<td>Directed through surface facing cranial opening.</td>
<td></td>
</tr>
<tr>
<td>Good window for <em>en bloc</em> resection of hippocampus and adjacent structures.</td>
<td></td>
</tr>
<tr>
<td>Good angle for approaching the posterior segment of the mesial temporal lobe.</td>
<td></td>
</tr>
<tr>
<td><strong>Basal surface: transsulcal or transgyral approaches</strong></td>
<td>Required cerebral retraction may damage basal temporal cortex.</td>
</tr>
<tr>
<td>Preserves the lateral temporal cortex and Meyer’s loop, because entrance into temporal horn is through its floor.</td>
<td>Risks damage to vein of Labbé.</td>
</tr>
<tr>
<td>May allow access to the posterior segment of the mesial temporal lobe, depending on the position of the vein of Labbé.</td>
<td>Language dysfunction may result from cortical incision or retraction of dominant fusiform gyrus.</td>
</tr>
<tr>
<td>Shorter route through brain to temporal horn than the lateral approaches.</td>
<td>Entrance into temporal horn through basal cisterns is technically more demanding because of deep, narrow window.</td>
</tr>
<tr>
<td><strong>Medial surface (anterior approach): transsylvian transcisternal approach</strong></td>
<td>Limited access to posterior part of medial temporal region.</td>
</tr>
<tr>
<td>Preserves lateral and basal temporal cortices.</td>
<td>Requires posterior retraction of temporal pole and apex of uncus.</td>
</tr>
<tr>
<td>Preserves Meyer’s loop, because entrance into temporal horn is through its medial wall.</td>
<td>Risk to structures in basal cisterns, especially oculomotor nerve.</td>
</tr>
<tr>
<td>Proximal control of internal carotid, posterior communicating anterior choroidal, and posterior cerebral arteries.</td>
<td></td>
</tr>
<tr>
<td>Allows recognition of medial surface anatomy before entrance into temporal horn.</td>
<td></td>
</tr>
<tr>
<td>May be combined with transsylvian-transinsular approach.</td>
<td></td>
</tr>
<tr>
<td><strong>Medial surface (posterior approaches): occipital interhemispheric and supracerebellar transtentorial approaches</strong></td>
<td>Requires occipital lobe or cerebellar retraction.</td>
</tr>
<tr>
<td>Preserves lateral and basal temporal cortices.</td>
<td>Hemorrhage with cutting through the tentorium.</td>
</tr>
<tr>
<td>Preserves optic radiations because entrance into temporal horn is through its medial wall and floor.</td>
<td>Difficult access to middle segment of mesial temporal region and access to all the anterior segment is not possible.</td>
</tr>
<tr>
<td>Avoids retraction of temporal lobe.</td>
<td>Lack of proximal control of posterior cerebral and anterior choroidal arteries.</td>
</tr>
<tr>
<td></td>
<td>Early exposure of venous drainage of arteriovenous malformation.</td>
</tr>
<tr>
<td></td>
<td>Greater working distance.</td>
</tr>
</tbody>
</table>
to enter the basal vein at the level of the inferior choroidal point, which is the limit between the anterior and middle portions of the medial temporal region. Entrance into the temporal horn directed through the rhinal sulcus on the lateral side of the uncus will expose only part of the temporal horn anterior to the choroidal fissure.

The posterior portion of the medial temporal region extends from the level of the quadrigeminal plate to the basal parieto-temporal line. The quadrigeminal plate sits at the junction of the ambient and quadrigeminal cisterns. The lateral wall of the quadrigeminal cistern is formed by the posterior part of the parahippocampal gyrus, isthmus of cingulate gyrus, and the anterior-most portion of lingula. The ventricular surface of the posterior portion is composed of the tail of the hippocampus, the anterior-most portion of lingula. The ventricular surface of the parahippocampal gyrus, isthmus of cingulate gyrus, and the quadrigeminal cistern is formed by the posterior part of the quadrigeminal plate.

The operative approaches to the medial temporal region may be classified into four groups: superior, lateral, basal, and medial, based on the surface through which the exposure is directed. The superior approach, the transsylvian-transinsular approach, is directed through the floor of the sylvian fissure near the anterior inferior part of the limiting sulcus of the insula. The lateral approach may be directed through any sulcus or gyrus of the lateral face of the temporal lobe, although the superior temporal gyrus is used rarely unless it is involved in the lesion. The approach is frequently directed through a resection of the anterolateral temporal cortex, referred to as an anterior temporal lobectomy. The basal approach may be directed through any sulcus or gyrus on the basal face of the temporal lobe. The medial approach is divided into an anterior variant, the transsylvian transcisternal approach is directed through the sylvian and crural cisterns, and a posterior group is directed through the occipital bone either above or below the tentorium in the occipital interhemispheric or supracerebellar transcontorial approaches. The advantages and disadvantages of each surgical approach to the medial temporal region are summarized in Table 3.

**General Considerations**

An understanding of the anatomic characteristics of the temporalis muscle, which occupies the temporal fossa, and the techniques available to deal with it during temporal lobe exposure is essential to achieving optimal exposure with minimal retraction (Fig. 6). The temporalis muscle resembles an open fan. It extends from the superior temporal line to the coronoid process of mandible. Its fibers converge and descend between the zygomatic process and the lateral side of the cranium to a tendon that attaches to the coronoid process. The muscle’s outer surface is covered by the temporal fascia, which is comprised by a single layer over the posterior three-quarters of the muscle and divides into superficial and deep layers on the outer surface of the anterior quarter of the muscle. The superficial layer attaches to the lateral border and the deep layer attaches to the medial border of the orbital rim and zygomatic arch. A fat pad and a temporal vein fill the space between the two fascial layers.

The frontal branches of the facial nerve course in a fat pad in the anterior temple area between the superficial layer of temporalis fascia and the galea, where they could be damaged during in the subgaleal elevation of the scalp flap. To protect the nerve, the superficial layer and sometimes both the superficial and deep layers are opened at the upper edge of the fat pad and the nerve with the fat pad and superficial layer of temporalis fascia are folded downward with the galea to prevent the damage to the nerves that would occur if the dissection was directed into the fat pad on the outer surface of the fascia. The approach is referred to as interfascial if only the superficial and not the deep fascia is elevated and is referred to as subfascial if both layers of the temporal fascia are elevated and reflected downward.

Once exposed, the temporal muscle may be mobilized purposefully in several different ways to reach specific areas of the temporal fossa. In all of these techniques, the temporal muscle must be detached from the calvarium. Careful subperiosteal elevation of the muscle using a sharp periosteal elevator offers the best chance of preserving the neural innervation, arterial supply, and venous drainage of the muscle, which courses directly on the periosteal surface (Fig. 6D). Use of a hot cutting current to elevate the delicate neural and vascular structures on the deep surface of the muscle may result in atrophy of the muscle and a poor cosmetic result. Preserving the vascular and nerve supply will reduce muscle atrophy, cosmetic deformity, and masticatory symptoms.

To expose the anterior temporal fossa area, the muscle must be detached from its anterior and superior insertion and folded downward and backward, as in the classic pterional approach. If a more posterior exposure is needed, it may be necessary to section a small anterior portion of the muscle parallel to the zygomatic arch, but this may result in masticatory symptoms and cosmetic deformity. Freeing the muscle from its posterior and superior insertions and mobilizing it anteriorly allows exposure of medium and posterior part of the middle fossa only, whereas detaching the muscle from its superior, anterior, and posterior attachments, plus sectioning the zygomatic arch and displacing it downward with the masseter, allows the temporal muscle to be reclined downward through the breach in the arch, exposing all the temporal fossa (Fig. 6H).

A common step in most temporal lobectomies is entry into the temporal horn, whether the approach is through the lateral, superior, basal, or medial surfaces (Figs. 1–5). The temporal horn is encountered approximately 2.5 cm from the temporal pole. There are several steps in completing the medial temporal resection after exposing the temporal horn. The steps, which can vary in order depending on the approach, include medial, anterior, lateral, and posterior disconnection of the hippocampus and removal of the portion of the amygdala located below the optic tract. The medial disconnection of
the hippocampus can be achieved by opening the choroidal fissure, the narrow cleft between the fimbria of the fornix and the thalamus, along with the attached choroid plexus. The choroid plexus is attached to the tenia thalami on the thalamic side of the choroidal fissure and to the tenia fimbria on the fornical side of the fissure. The tenia are thin, fragile ependymal membranes. The fissure is opened by dividing the tenia fimbria rather than the tenia thalami because opening the tenia thalami risks damaging the veins passing through it that drain the optic radiations and sublenticular part of the internal capsule. The veins passing through the tenia fimbria are very small compared with those draining through the tenia thalami.

The anterior disconnection includes separating the head of the hippocampus from the amygdala by using the uncal recess as a landmark for carrying the exposure through the medial aspect of the uncus. The posterior disconnection involves sectioning the hippocampus and parahippocampal gyrus as far posteriorly as indicated by electrophysiologic and neuroradiologic studies. The partial amygdalar resection usually is completed using subpial dissection in front of the uncal recess. The superior part of the amygdala, the part in close apposition to the optic tract, branches of the anterior choroidal and posterior cerebral arteries, and the lower surface of the lentiform nucleus, is preserved (Figs. 3 and 4).

Superior Surface

The transsylvian-transinsular approach is directed through the superior surface of the lobe (Fig. 7). The head is turned 30 degrees toward the contralateral side with the posterior ramus of the sylvian fissure parallel to the surgeon's line of sight to provide a good viewing angle from anterior toward the posterior elements of the medial temporal region (Figs. 6G and 7). The approach is directed through the anterior part of the fissure. Excessive rotation of the head to the side opposite the approach is avoided because that shifts the line of view over the highest upward projecting part of the temporal lip of the sylvian fissure. A frontotemponophosphenoidal (pterional) bone flap is elevated and the roof and lateral wall of the orbit are thinned with a drill up to the lateral part of the superior orbital fissure. After opening the dura, the sylvian fissure is opened widely from lateral to medial, beginning 2 cm behind the pars triangularis and exposing forward to the chiasmal, carotid, and cranial cisterns (Figs. 7, B and C). The limen, the anterior third of the lower part of the insula, and the proximal part of the M2 is exposed. Usually, the inferior trunk of the middle cerebral artery must be elevated away from the inferior segment of the limiting sulcus of the insula. Small branches that originate from the inferior trunk and pass through the limiting sulcus may need to be sacrificed. A 1.5-cm incision directed downward and medially approximately 45 degrees toward the midpoint of the cavernous sinus lateral wall is completed in the anterior sector of the inferior portion of the limiting sulcus of the insula (Fig. 7, D and E). An alternative that carries less risk to the optic radiations in the roof of the temporal horn is incising the planum polare on the medial side of the limen and entering the amygdala from that trajectory. The incision in the anterior inferior part of the circular sulcus, limen, and the planum polare medial to the limen exposes the amygdala in the anterior uncinal segment. Removal of the lower and lateral parts of the amygdala provides entry into the temporal horn. The anterior uncinal area is removed using subpial suction, taking care to preserve the anterior choroidal and posterior communicating arteries, the oculomotor nerve, basal vein, and optic tract, which are visible through the pia arachnoid. After entering the temporal horn through the amygdala, the choroid plexus is displaced toward the roof of the temporal horn, and the choroidal fissure is

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**FIGURE 6.** Images showing the craniotomy procedure for exposure of temporal lobe. A, insert shows the skin incision, which extends more posteriorly above the ear than with the usual pterional craniotomy. The scalp and temporalis muscle have been elevated to show the bone flap for a temporal lobectomy. The bone flap, centered below the squamosal suture, will be smaller if only a transsylvian or transbasal or direct temporal lobectomy is needed and will be larger if cortical mapping and electrocardiography are to be carried out. A cuff of fascia remains attached along the superior temporal line to aid in a closure. B, interfascial dissection of the temporalis fascia has been completed. In this exposure, the superficial layer of temporalis fascia has been incised and folded down with the galea to preserve the branches of the facial nerve to the frontalis muscle, which course on the outer surface of the temporalis fascia. C, subfascial approaches in which both the superficial and deep layers of temporalis fascia are elevated to preserve the branches of the facial nerve. The authors prefer the interfascial shown in B. It is best to avoid cutting into the muscle, which may result in scarring, atrophy, cosmetic deformity, and disorders of mastication. D, temporalis muscle has been folded downward. The careful handling of this muscle is important in obtaining a good cosmetic result. The arterial supply, venous drainage, and nerve supply all course on the deep surface of the muscle directly on the periosteal surface of the bone. Using a hot cutting current to elevate the muscle will often damage the muscle's nerve and vascular supply with resulting temporalis atrophy and a poor cosmetic result. It is best to elevate the muscle using careful subperiosteal dissection with a sharp periosteal elevator. E, exposure of the right temporal lobe used in cases in which the preoperative studies have clearly defined a lesion in the medial temporal lobe and there is no need to expose the area above the sylvian fissure. F, more extensive exposure above the sylvian fissure is used if cortical mapping and electrocardiography are needed to define the extent of resection and the seizure focus. G, pterional exposure used for the transsylvian-transinsular and transsylvian-transcisternal approaches. The insert shows the site of the scalp incision. H, magnetic resonance imaging scan with image guidance showing the operative trajectory both before and after dividing the zygomatic arch. The green image shows the trajectory obtained if the zygomatic arch remains and the muscle is folded downward over the upper edge of the arch. The yellow image shows the lower trajectory obtained after dividing the zygomatic arch and folding the muscle down between the divided edge of the arch. A, artery; Cent., central; Fiss., fissure; Front., frontal; Frontozyg., frontozygomatic; Inf., inferior; M., muscle; Mid., middle; N., nerve; Postcent., postcentral; Precent., precentral; Squam., squamosal; Sup., superior; Supramarg., supramarginal; Temp., temporal; V., vein; Zygo., zygomatic.
MEDIAL TEMPORAL REGION APPROACHES

A. Temp. M.
Frontozygo. Suture
Pterion
Sup. Temp. Line

B. Temp. M.
Frontozygo. Suture
Temp. Fascia
(Deep Layer)
Sup. Temp. Line

C. Temp. M.
Frontozygo. Suture
Zygo. Arch
Sup. Temp. Line
Temp. Fascia

D. Temp. M.
Deep Temp. A., V., N.

E. Inf. Temp. Gyrus
Mid. Temp. Gyrus
Sup. Temp. Gyrus
Sylvian Fiss.
Front. Lobe

F. Inf. Temp. Gyrus
Mid. Temp. Gyrus
Sup. Temp. Gyrus
Sylvian Fiss.
Inf. Front. Gyrus
Supramarg. Gyrus
Cent. Sulcus
Parietal Gyrus
Precentral Gyrus

G. Sup. Sylvian V.
Sylvian Fiss.
Front. Lobe

H. Temp. Lobe
opened through the tenia fimbriae in the area lateral to the cerebral peduncle while preserving the anterior choroidal artery, optic tract, and basal vein. Opening the choroidal fissure through the tenia fimbriae avoids damaging the veins that cross the thalamic side of the fissure and drain the optic radiations and sublenticular part of the internal capsule (Fig. 7E). Opening the choroidal fissure exposes the structures in the ambient cistern. The laterally directed branches of the anterior choroidal artery and the P2 segment of the posterior cerebral artery that pass to the hippocampal sulcus are obliterated and cut, whereas all those that pass laterally beyond the collateral sulcus must be preserved. The next step is hippocampal disconnection. An incision around the hippocampus and the uncral recess is extended downward into the collateral and rhinal sulci. The posterior edge of the resection of the hippocampus and parahippocampal gyrus is located approximately 1 cm behind the inferior choroidal point, which corresponds to the approximate level of the lateral geniculate body, posterior border of the cerebral peduncle, lateral mesencephalic sulcus, and the ascension of the fimbria to form the crus of the fornix (Fig. 1G). With disconnection, the head and body of the hippocampus and part of the parahippocampal gyrus are removed en bloc (Fig. 7F). The last steps are removal of the remaining amygdala at the anterior edge of the exposure and the subpial removal of the remainder of the uncus, using the optic tract as the superior limit of the resection. The upper medial part of the amygdala adjacent the claustrum, optic tract, and lentiform nucleus is not removed.

The advantage of the superior approach is that it preserves the lateral and basal temporal cortex involved in higher cortical functions and language and can be combined with the transsylvian-transinsular approach. Disadvantages are the small working area, greater technical skill required to complete en bloc resections, and the risks to optic radiations in the roof of the temporal horn (3).

**Lateral Surface**

Most approaches directed through the lateral surface are performed for epilepsy. The classic standard lobectomy that involved a large cortical incision extending 6 cm behind the temporal tip on the nondominant side and 4.5 cm on the dominant side have given way to more limited lateral resections because most ictal events are triggered in mesial structures (5, 39). The anterolateral approach of Spencer, in which the lateral cortical resection includes 3 to 3.5 cm of the lateral cortex below the superior temporal gyrus, was the model used in this study (Fig. 8). The temporal horn is entered after the superficial block of tissue is removed. The head is rotated approximately 30 degrees to the contralateral side of the approach and the vertex is tilted downward to facilitate the view into the temporal horn and along the choroid fissure. A pretemporal craniotomy is completed to expose the anterior two thirds of the temporal lobe, the sylvian fissure, and the floor of the middle fossa (Figs. 6E and 8B). The lobe can be entered through any gyrus or sulcus on the lateral temporal surface; however, the superior temporal gyrus usually is avoided because Heschl's gyrus, the site of the primary auditory projection area, is on the upper surface and the insula is on the medial surface of the gyrus (Fig. 2, B and F). Magnetic resonance imaging scans of coronal sections will aid in selecting a route to the temporal horn, which is opened through its lateral wall in a lateral to medial trajectory (Fig. 8C). The medial temporal resection is completed using the same steps used during the transsylvian-transinsular approach. The subpial resection of the superior portion of uncus and amygdala is the last step in the procedure (Fig. 8, D–F). To visualize the most posterior structures of the temporal horn, it is necessary to direct the view of the microscope from anterior to posterior along the anteroposterior axis of the head and temporal horn. A useful landmark for the upper boarder of this resection is a line traced from the bifurcation of the internal carotid artery to

**FIGURE 7.** Images showing the transsylvian-transinsular approach. A, coronal section through the right temporal lobe near the inferior choroidal point. In this approach, the temporal horn is reached through the anterior portion of the inferior limiting sulcus of the insula, after widely opening the sylvian fissure. During an amygdalohippocampectomy for epilepsy, the amygdala, uncus, hippocampus, and parahippocampal gyrus are removed (horizontal blue lines). The medial disconnection of the medial temporal structures is achieved by opening the choroidal fissure. The lateral disconnection is directed through the collateral eminence and sulcus. B–F, stepwise cadaveric dissection demonstrating the transsylvian transinsular approach. B, right pterional craniotomy with exposure of the frontal and temporal lobes in an anatomic specimen. The sylvian fissure has been opened to expose the anterior portion of the insula and the bifurcation and M2 branches of the middle cerebral artery. C, anterior portion of the inferior limiting sulcus of the insula has been exposed. The M2 branches that course along the inferior limiting sulcus must be mobilized gently. D, M2 segment has been elevated and the inferior limiting sulcus has been opened to expose the temporal horn, hippocampus, choroid plexus, collateral eminence, and roof of the temporal horn. E, medial disconnection of the temporal lobe is accomplished by opening the choroidal fissure through the tenia fimbriae proceeding backward from the inferior choroidal point. The choroid plexus remains attached to the tenia in the roof of the temporal horn. F, amygdalohippocampectomy has been competed, exposing the vascular elements in the ambient cistern. G and H, pre- and postoperative studies of an arteriovenous malformation involving the anterior and middle portions of the left medial temporal region. A transsylvian-transinsular approach was combined with a transsylvian-transcisternal approach to achieve a complete removal. G, preoperative magnetic resonance imaging scans (upper left, axial; upper right, sagittal) and vertebral angiograms (lower left, anteroposterior view; lower right, lateral view). H, postoperative carotid (upper left, anteroposterior view; upper right, lateral view) and vertebral angiograms (lower left, lateral view; lower right, anteroposterior view) showing complete removal. Chor., choroid; Chorid.; Cist., cistern; Coll., collateral; Emin., eminence; Fiss., fissure; Front., frontal; Hippo., hippocampus; Inf., inferior; Ins., insular; Lat., lateral; Lim., limiting; M1, M2, M4, segments of the middle cerebral artery; Mes., mesencephalic; P.C.A., posterior cerebral artery; Plex., plexus; Sup., superior; Temp., temporal; V., vein.
the inferior choroidal point (carotid-choroidal line or Wen's line) (48) because there is no clear demarcation between the gray matter of the amygdala below and the basal ganglia above. Coronal cross-sections through the amygdala reveal that it blends directly into the globus pallidus above (Fig. 3D).

Advantages of the lateral approaches that have made it the favored approach for many epilepsy surgeons are that the lobectomy provides a good window for en bloc resection of the hippocampus and adjacent structures, the easy access to the hippocampus, and the fact that it is less technically demanding than the other routes to the area. The disadvantages are that it produces lesions of the lateral temporal cortex, damages the optic radiations if extended posteriorly, and requires greater depth to the temporal horn than through the basal or superior approaches.

**Basal Surface**

The head is rotated approximately 75 degrees to the contralateral side of the approach (Fig. 9). The craniotomy is similar to that described for the lateral approaches, with generous exposure of the middle fossa floor to reduce brain retraction and to improve the angle of view through the basal surface of the lobe (Fig. 9, B and C). A low exposure is facilitated by section of the zygomatic arch and downward retraction of the temporal muscle, which facilitates the view from lateral to medial and from inferior to superior. This approach is referred to as the pretemporal-zygomatic approach. After opening the dura, the temporal lobe is elevated to expose the basal surface. The vein of Labbé should be preserved. The basal cisterns may be opened and cerebrospinal fluid aspirated to facilitate the exposure. The temporal horn can be entered through the collateral and rhinal or occipitotemporal sulci or the fusiform or parahippocampal gyri. The more medial the site of the corticotomy, the more vertical will be the trajectory to the ventricle. Even if the collateral and rhinal sulci are chosen, the direction of view through the temporal horn will be from medial to lateral. Once inside of the temporal horn, the medial disconnection directed between the fimbria and the choroid plexus is completed to expose the ambient cistern (Fig. 9, D and E). In the basal approaches, the lateral disconnection at the level of the collateral eminence and lateral edge of the hippocampus is completed at the time the temporal horn is being entered through the lower temporal surface. The anterior and posterior disconnection of the hippocampus and resection of the amygdala and remaining uncus are similar to the lateral approach (Fig. 9F).

Advantages of the basal approach are the entry into the temporal horn through the floor with reduced risk to the optic radiations, the shorter route to the temporal horn than with the lateral approaches, and the possibility of accessing the posterior part of the medial temporal lobe depending on the position of the vein of Labbé. The disadvantages are the retraction required to reach the basal surface, especially medially, the language areas in the region of the fusiform gyrus of the dominant hemisphere, and the risk to the vein of Labbé.

**Medial Surface**

The approaches directed through the medial surface are divided into an anterior route, the transsylvian-transcisternal approach, and two posterior routes, the occipital interhemispheric and the supracerebellar transtentorial approaches. The posterior approaches are used commonly for arteriovenous malformations, tumors, or cavernomas of the middle and posterior portion of the mesial temporal region and less frequently for resections for epilepsy.

**Transsylvian-Transcisternal Approach**

The craniotomy is the same as that used for the transsylvian-transinsular approach (Figs. 6G and 10). After extensive opening of the sylvian fissure and basal cisterns, the bridging veins from the temporal pole that enter the sphenoparietal or cavernous sinuses are obliterated and divided to allow mobilization of the...
MEDIAL TEMPORAL REGION APPROACHES

A

B

C

D

E

F

G

H

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temporal pole. The arachnoid fibers between the uncus and the oculomotor nerve, vascular elements of the carotid and crural cisterns, and tentorium are cut to grant access to the anterior part of the medial temporal region (Fig. 10, B and C). The temporal pole is retracted to expose the anterior sector of the medial temporal region. The anterior choroidal artery is followed distally from its origin from the internal carotid artery and as far as possible around the uncus (Fig. 10D). It is difficult to visualize the inferior choroidal point where the anterior choroidal artery enters the temporal horn before resection of the medial part of the uncus because it is hidden behind the apex of the uncus. An imaginary line is traced from the anterior end of rhinal sulcus, which corresponds to the anterior limit of the uncus and separates it from the planum polare, to the most distal visible point of the anterior choroidal artery. The subpial resection of part of the uncus medial to this line provides access to the most medial and anterior part of the temporal horn (Fig. 10E). The steps necessary to complete the medial temporal resection resemble those accomplished in other approaches (Fig. 10F). Opening the floor of the stem of the sylvian fissure by dividing the limen insulae will enlarge the basal and posterior view a few millimeters.

Advantages of the medial approach are avoidance of the lateral and basal temporal cortex and optic radiations, access for proximal control of the internal carotid, anterior choroidal, posterior communicating, and posterior cerebral arteries, and the view of the medial temporal surface before entering the temporal horn. The disadvantages are lack of access to the posterior part of the medial temporal region, the required retraction of the temporal pole and apex of the uncus, the risk to the oculomotor nerve, and the fact that the approach through the cisterns is more technically demanding.

Occipital Interhemispheric Approach

The patient can be positioned in the sitting, prone, or park bench position. An occipital craniotomy is performed, exposing the superior sagittal and transverse sinuses. The occipital pole is retracted laterally and superiorly to expose the falx, tentorium, straight sinus, and arachnoid of the quadrigeminal cistern (Fig. 11, A–C). Usually, there are no bridging veins entering the posterior portion of the superior sagittal sinus below the lambdoid suture. The tentorial incision is made parallel to and 1 cm from the straight sinus, and the quadrigeminal and ambient cisterns are exposed (Fig. 11B). Opening the tentorium allows the medial edge of the tentorium to fall away from the lower surface of the parahippocampal gyrus and aids in exposing the posterior and middle parts of the medial temporal region and the adjacent quadrigeminal and ambient cisterns. The retraction of the occipital pole can be extended forward to expose the posterior portion of the medial temporal lobe. Changing the angulation of the microscope and retracting the tentorial surface of the cerebellum caudally exposes the middle and posterior parts of the medial temporal region, including the posterior portion of the parahippocampal gyrus, the isthmus of the cingulate gyrus, and the anterior portion of the lingula (Fig. 11, B and C). The posterior approaches infrequently involve en bloc cortical resection and most commonly involved direct cortical incision over lesions such as cavernoma and tumors or resections around arteriovenous malformations after exposure and management of feeding arteries and draining veins.

Supracerebellar Transtentorial Approach

The patient is placed in the sitting, prone, or park bench position. The craniotomy extends from the transverse and sigmoid sinuses to just above or into the foramen magnum to provide multiple working corridors and access to the cisterna magna with cerebrospinal fluid drainage to relax the cerebellum (Fig. 11, D–H). Initially, the approach can be directed along the midline. Bridging veins between the tentorium and cerebellum should be obliterated and cut if it seems that they may be stretched and torn. Opening the arachnoid membrane of the quadrigeminal cistern exposes the Galenic venous complex. The angle of vision should be redirected laterally toward the junction of the quadrigeminal and ambient cisterns. The
arachnoid covering the cisterns is opened, exposing the trochlear nerve and the superior cerebellar and posterior cerebral arteries (Fig. 11F). Dividing the tentorium from below starts at the free edge and extends posteriorly. The free edge is retracted laterally to expose the middle and posterior portions of the medial temporal region, the ambient cistern, and the posterior part of the crural cistern (Fig. 11, G and H). The approach from here is based on the lesion type.

The advantages of the posterior approaches are that they leave the lateral and most of the basal cortex and the optic radiations undisturbed, avoid temporal lobe retraction, and provide access to the posterior and middle parts of the medial temporal region. The disadvantages are the occipital lobe or cerebellar retraction, risk of hemianopsia with occipital lobe retraction, difficulty in accessing the anterior parts of the mesial temporal area, the lack of proximal arterial control, early exposure of the venous drainage, and greater working distance.

**DISCUSSION**

Important anatomic and functional structures confronted in the surgical approach to the medial temporal region include the lateral and basal temporal cortices; Wernicke’s area; the optic radiations, including Meyer’s loop; the structures in the sylvian fissure; and the carotid, interpeduncular, crural, and ambient cisterns, including the middle cerebral, internal carotid, posterior communicating, anterior choroidal, and posterior cerebral arteries, the superficial sylvian, deep middle cerebral, and basal veins, and the oculomotor and trochlear nerves. Lesions in this area include a wide range of pathological features, including epileptogenic areas, arteriovenous and cavernous malformations, tumors, and traumatic contusions that are the subject of a broad range of neurosurgical specialties.

Most of the approaches to the medial temporal region were devised for the treatment of epilepsy (4, 13–15, 17, 21, 23, 24, 27, 28, 34, 40, 45, 52) or arteriovenous malformations (2, 7–10, 16, 18, 22, 23, 26, 38, 41–43, 47). The complex anatomy of the medial temporal region and position of the various pathological features have led to approaches that reach it through the lateral, basal, medial, and superior surfaces of the lobe (8, 9, 43). The approaches through the lateral and superior surfaces have been predominately for resections for epilepsy and tumors of the anterior and middle portions of the medial temporal lobe. The approaches directed through the medial surface from posteriorly and through the basal surface have been carried out predominately for arteriovenous malformations and tumors in the middle and posterior portions of the medial temporal lobe, in which cortical incisions directly over mass lesions or early vascular control is more important than cortical and en bloc resections as required in epilepsy.

Partial temporal lobectomy was first described for the surgical treatment of epilepsy in 1925 (12). In 1958, Niemeyer (24) first described selective amygdalohippocampectomy through the middle temporal gyrus. In 1985, Yaşargil et al. (52) introduced selective resection of amygdala and hippocampus through a transsylvian-transsinsular approach. These approaches either dealt with the lateral temporal cortex or produced occasional lesions of the optic radiations. The approaches through the basal surface were proposed as a way to avoid the dominant lateral temporal cortex involved in higher cortical functions and the optic radiations in the roof and/or lateral wall of the temporal horn (11, 17, 23, 25, 27, 36). Experience with these approaches, however, revealed them to require significant cerebral retraction, risking injury to the vein of Labbé and the temporal cortex (10, 45). In addition, cortical mapping has revealed areas involved in language function along the dominant basal sector of the temporal lobe, especially along fusiform gyrus (20, 33).
In 1998, Vajkoczy et al. (45) described the transsylvian-transcisternal approach, which entered directly into the medial temporal surface. This route through the sylvian fissure and basal cisterns leaves the lateral and basal temporal cortexes untouched, and access through the roof and lateral wall of the temporal horn was avoided, thus, preserving the optic radiations. The approach was used in 32 patients with medial temporal lobe epilepsy, half of whom had lesions such as cavernomas or tumors. Disadvantages of this approach are that it accesses predominantly the medial aspect of the medial surface, the difficulty in visualizing the medial temporal area behind the apex of the uncus, and the risks to the structures in the basal cisterns, especially the oculomotor nerve. The recent work of Sincoff et al. (36) and Rubino et al. (31), emphasizing the relationship between the optic radiations and the superior and lateral walls of the temporal horn, support the role of basal and medial approaches in preserving the optic radiations (31).

The posterior approaches that are directed through the medial temporal surface are the occipital interhemispheric and the supracerebellar transtentorial approaches (8, 9, 19, 29, 32, 35, 37, 46, 49, 53). Both provide satisfactory exposure of the posterior portion of the medial temporal region and, with further retraction, the middle sector also can be reached. The supracerebellar transtentorial approach was reported by Voigt and Yaşargil (46), in 1976, for removal of a cavernoma into the parahippocampal gyrus. Yonekawa et al. (53) used the same approach to treat 16 patients with lesions in or around the posterior portion of the medial temporal region. The occipital interhemispheric approach was proposed by de Oliveira et al. (8, 9) to treat arteriovenous malformations of the posterior portion of the medial temporal region, although they noted the disadvantages in vascular surgery of difficulty in gaining proximal control of arterial afferents and premature access to the venous drainage of the lesion. Smith and Spetzler (37) also used the occipital interhemispheric approach to treat seven patients with lesions in the posterior part of the medial temporal region and noted that the uncus could be reached (44).

Controversy remains as to the best approach for the treatment of temporal lobe epilepsy. Currently, the two most common approaches are the anterior temporal lobectomy with amygdalo-hippocampectomy and the transsylvian-transsural selective amygdalohippocampectomy (40, 48, 52). The controversy between tailored resection versus anatomic resection, anterior temporal lobectomy versus selective amygdalohippocampectomy, and selective transsylvian versus selective transcortical resection, continues (4, 14, 15, 21).

In dealing with vascular lesions, an additional consideration is gaining proximal arterial control, and in the case of an arteriovenous malformation, locating the position of the venous drainage. In 1982, Heros (16) used a transcortical approach through the inferior temporal and fusiform gyri to treat three patients with arteriovenous malformations of the medial temporal region. In 1986, Solomon and Stein (38) described a similar approach through the inferior temporal, fusiform, or parahippocampal gyri. In 1994, de Oliveira et al. (9) not only divided the medial temporal region into an anterior, middle, and posterior portions, but also proposed the pretemporal approach to treat arteriovenous malformations of the anterior portion, the subtemporal approach through the occipitotemporal sulcus to reach lesions in the middle portion, and the occipital interhemispheric approach for arteriovenous malformations of the posterior portion of the medial temporal region. In 2002, Ikeda et al. (18) described a transchoroidal approach through the inferior temporal gyrus to treat a patient with a medial temporal arteriovenous malformation. In 2004, Du et al. (10) proposed a tangential resection of medial temporal arteriovenous malformations through the orbitozygomatic approach, presenting 10 patients, nine of whom the posterior cerebral artery have been exposed. F, the right half of the tentorium has been divided to expose the middle and posterior parts of the medial temporal region and the ambient and the posterior part of the crus cistern. The parahippocampal gyrus and the P2P segment of the posterior cerebral artery are exposed in the ambient cistern and the P2A is exposed in the posterior part of the crus cistern. G, the middle and posterior parts of the parahippocampal gyrus and the adjacent part of the hippocampus have been removed. The lateral margin of the resection was directed through the collateral sulcus. The choroid plexus remains attached to the lower margin of the thalamus in the area beside the lateral geniculate body. H, magnetic resonance imaging scan with image guidance showing the exposure extending along the medial temporal region and parahippocampal gyrus to the posterior part of the crus cistern. A., artery; Br., branch; Cer., cerebral; Chor., choroid; CN, cranial nerve; Coll., collateral, colliculus; Gen., geniculate; Inf., inferior; Int., internal; Lat., lateral; Occip., occipital; P2A, anterior portion of the P2 segment of the posterior cerebral artery; P2P, posterior portion of the P2 segment of the posterior cerebral artery; P3, segment of the posterior cerebral artery; Parahippo., parahippocampal; Par., Occip., parieto-occipital; P.C.A., posterior cerebral artery; Plex., plexus; S.C.A., superior cerebellar artery; Str., straight; Suboccip., suboccipital; Sup., superior; Tent., tentorial, tentorium; Transv., transverse; V., vein; Ve., vermian.
obtained a complete resection of arteriovenous malformations of medial temporal region. These authors affirm that the success of the technique depended on the orbitozygomatic approach; however, we agree with other authors that good results after medial temporal arteriovenous malformation resection depend more on the circumferential microsurgical dissection and wide opening of the cisterns than on the orbitozygomatic trajectory (6, 51).

Combination of the approaches mentioned above have been reported. Yaşargil and Abdulrauf (50), de Oliveira et al. (9), and Ulm et al. (44) proposed the combination of a transsylvian-transcisternal approach with a transsylvian-transinsular approach. In 2004, Miyamoto et al. (23) reported the use of a combined subttemporal-transtemporal transchondal approach to treat 21 patients with medial temporal lesions. Combination of approaches can be a useful surgical solution and should be considered when the lesion involves two portions of the medial temporal lobe.

**CONCLUSION**

Each of the several techniques developed to treat medial temporal lesions have technical or functional drawbacks that should be considered in treating a given patient. Dividing the medial temporal region into subsections allows for a more precise analysis, not only of the anatomic relationships, but also of the possible choices of approaches capable of safely delivering the lesion. The systematization used here provides a rational selection of one or a combination of approaches.

**REFERENCES**

MEDIAL TEMPORAL REGION APPROACHES

COMMENTS

The authors describe a detailed microsurgical anatomy of the medial temporal region and discuss the surgical approaches to this complex area. They use a classification based on dividing the medial temporal region into three parts, which provides a rational approach to each area as different routes are used to reach the anterior, middle, and posterior medial temporal lobe.

We usually use a combination of the temporopolar, transsylvian, and subtemporal routes called the “pretemporal approach” for anterior medial temporal lesions, such as arteriovenous malformations, cavernomas, and tumors (1, 3-6). The exposure of the temporal lobe followed by a sylvian fissure opening achieved in the pretemporal approach allows a posterior retraction of the temporal lobe with less risk to damage of the temporal cortex. This maneuver also increases the surgical field in the transsylvian transcisternal approach as it widely exposes the region of the uncus and the vascular and neural structures around it. A transsylvian transcisternal approach can be associated with transsylvian transventricular (temporal horn) approach to gain access to the anterior portion.

The authors comment that, in cases in which a transsylvian transventricular approach is used, the sacrifice of some arterial branches coming from the M2 portion of the middle cerebral artery that crosses the anterior portion of the inferior limiting sulcus is sometimes necessary. We think that dissecting an increased length of the inferior trunk of the M2 allows its mobilization; consequently, those branches can be retracted out to the region where the corticectomy will be performed at the inferior limiting sulcus to achieve the temporal horn of the lateral ventricle. For this purpose, we use a different landmark to gain access to the ventricular cavity: the corticectomy at the inferior limiting sulcus is performed slightly posterior to the limen insula (1.5 cm in length), and its direction follows the direct visualization of the tentorial edge as a landmark. It allows a safer procedure, as the corticectomy will not be directed more medial than the free edge of the tentorium, and the damage to the basal ganglia nuclei and thalamus will be avoided.

For subpial resection of the uncus and amygdala, Wen et al. (7) describe the anterior choroidal artery when it reaches the superior part of the uncus during its medial curve from the carotid artery to the inferior choroidal point as a superior limit to the resection of the amygdala. However, we usually perform an en bloc resection for medial temporal lobe epilepsy by the transsylvian transcisternal combined with transsylvian transventricular approach as described by Yaşargil (8). It allows a more direct visualization of the vascular and neural anatomy around this region, providing a safe aspiration of the amygdala up to the optic tract as the superior limit of resection.

The middle portion of the medial temporal region can be accessed by a subtemporal route through a transsulcal (temporoccipital) or cortical incision on the superior, middle, inferior, or fusiform gyrus (1, 2, 6).

The posterior portion of the medial temporal region can be accessed by the occipitotemporal sulcus or through an interhemispheric occipital approach. For smaller lesions, we have used a suprachiasmatic infratentorial approach.

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The authors describe the numerous surgical approaches to the medial part of the temporal lobe. The goals of this study were to examine the surgical approaches, to divide the approaches into groups based on anatomical characteristics, and to review the advantages and disadvantages of the approaches in relation to the part of the medial temporal region to be accessed.

After reviewing the anatomy of the temporal lobe, the authors have pointed out important surgical pitfalls and anatomical structures confronted in the surgical approaches, including temporal cortices, Werneck’s area, optic radiation, vein of Labbé, structures in the sylvian fissure, arteries, superficial and basal veins, oculomotor, and trochlear nerves.

The authors systematically outlined the technical advantages and disadvantages of the different surgical approaches in regards to the structures. Unfortunately, uncinate fasciculus and neuropsychological consequences have not been taken into consideration, probably because this study is a cadaveric head anatomical analysis.

The authors claim that the “systematization” of three surgical approaches of the medial temporal regions will provide the basis for selection of a combination of approaches. In fact, other considerations (epileptic zone, epileptic diffusion, seizure control, neuropsychological data, and positron emission tomography studies) are also taken into consideration when deciding which type of resection is needed and which type of approach is required. For example, the authors state that “the controversy between tailored resection versus anatomical resection, anterior temporal lobectomy versus selective amygdalohippocampectomy, and selective transsylvian versus selective transcortical resection continues.” Such controversies are mainly because of seizure control and are not caused by concerns regarding technical surgical approaches.

Neurosurgeons do not master all the different surgical approaches. They tend to perform only one or two approaches to which they are accustomed. Each surgeon’s preference is probably the most important safety criteria and has to be fully respected.

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Campero et al. review the temporal lobe anatomy and provide an overview of the various surgical approaches that have been used for the treatment of assorted temporal lobe pathologies. Temporal lobe anatomy can be difficult to gain confidence with, and another well-organized, well-illustrated review is helpful. This article provides the necessary background to a discussion of the surgical technique. It highlights the importance of anatomy in surgery. We are reminded that surgery is anatomy and hemostasis. Image guidance can be enormously useful in surgery of the temporal lobe, particularly for those less familiar with the territory, but it is not a substitute for solid background knowledge of neuroanatomy.

Although there may be a multitude of alternative strategies in approaching the medial temporal lobe, each has its advantages, disadvantages, and role in the surgical armamentarium. Procedures for intractable epilepsy use lateral or transsylvian approaches, and a number of interesting, newer strategies, have been recently reported. Unquestionably more important than any theoretical advantage of one compared with another, however, is the individual surgeon’s familiarity and confidence with the selected route. Arteriovenous malformations, tumors, and lesional epilepsy are more variable in their location, extent, and needed exposure, and an awareness of the whole spectrum of surgical possibilities is essential. In this regard, this article will be a resource for any neurosurgeon operating on the temporal lobe.

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