17 Anteromesial Temporal Lobectomy

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Anteromesial temporal lobectomy (AMTL) is the most commonly performed surgical procedure for the treatment of patients with medically refractory epilepsy. Although temporal lobe epilepsy (TLE) is more common in adults, AMTL is still a frequently performed procedure in surgical treatment of children with epilepsy. AMTL constitutes 30 to 44% of all surgical resections in published pediatric epilepsy series compared with reported rates of 62 to 73% of cases in adult epilepsy surgery series.[1–5]

The main reason for this discrepancy is related to the differences in neuropathological substrates causing epilepsy in children and adults. Mesial temporal sclerosis (MTS) is the most common substrate in adult epilepsy patients, and it occurs with a greater frequency compared with low-grade neoplasms and developmental lesions such as cortical dysplasia, which are more commonly seen in the pediatric age group. AMTL is a very effective surgical intervention in controlling medically refractory seizures in well-selected pediatric patients, and its efficiency in the treatment of children with intractable TLE has been demonstrated in many surgical series.[1,2,6–11]

This chapter gives a step-by-step description of the surgical technique we use for AMTL. The surgical technique may change based on the underlying lesion and extent of the epileptogenic zone, especially in patients with cortical dysplasia. Briefly, all patients undergo a comprehensive presurgical assessment by our pediatric epilepsy service including a detailed clinical examination, magnetic resonance imaging (MRI) with epilepsy protocol, electroencephalography (EEG), and long-term EEG-video monitoring to obtain ictal and interictal electrophysiological data. Positron emission tomography/single photon emission computed tomography, neuropsychological assessment, and intracarotid amobarbital procedure (Wada test) are among other commonly used diagnostic modalities and tests. Despite all of these tests, locating the epileptogenic zone remains problematic in a significant number of children with TLE, and these patients frequently are candidates for invasive monitoring. Further details on patient selection criteria/preoperative workup as well as surgical techniques for other pathologies can be found in related chapters in this book.

Historical Evolution of the Surgical Technique

Temporal lobe resection in epilepsy surgery is not a standard technique.[12,13] Because temporal lobectomy suggests removal of the whole temporal lobe, ***anterior*** or ***anteromesial temporal lobectomy*** are the more appropriate terms for the technique commonly used by epilepsy surgeons. Early variations of the surgical technique we use today were developed in the 1950s. The first application of the technique was a temporal neocortical resection without removing mesial temporal structures. Then, Wilder Penfield and colleagues reported better results by resecting the hippocampus and uncus along the temporal neocortex.[14–16] After the initial studies regarding the role of hippocampus in memory function, the surgical technique evolved toward electrophysiologically tailored temporal lobectomy with significant preservation of the hippocampus.[12,13,17,18] Also in the mid 1950s, Niemeyer described selective transcortical amygdalohippocampectomy.[19] Later, Yasargil and colleagues developed a selective amygdalohippocampectomy technique through the transsylvian approach and reported impressive seizure control rates without removing temporal neocortex.[20] The details of this approach are discussed in the next chapter.

At the Montreal Neurological Institute (MNI), Rasmussen performed anterior temporal lobectomy by including uncus and amygdala and used electrocorticography to determine the extent of hippocampal resection. His approach was to remove the anterior 1 to 1.5 cm of the hippocampus.[21–25] Conversely, Feindel and colleagues, in the same institution (MNI), routinely avoided the removal of hippocampus to preserve memory functions but aggressively resected the amygdala.[26–28] Then Goldring and colleagues described an anterior temporal lobectomy technique that spares the amygdala.[29] Today, the most commonly used technique is the resection of anterior temporal neocortex and mesial temporal structures, including amygdala and hippocampus. Even this technique has some variations, including en bloc resection of both neocortex and mesial temporal structures that was described by Falconer and later applied by Polkey and Crandal.[30] Another modification of the technique was described by Spencer and colleagues at Yale.[31] Spencer's technique is the most commonly used technique today, although many differences among epilepsy surgeons of the application of this surgical technique still exist. One of the main differences is resection length of anterior temporal lobe. The majority of epilepsy surgeons do not exceed a 4-cm neocortical resection length (from the tip of anterior temporal lobe) in the dominant hemisphere, whereas the length of resection may increase up to 5.5 to 6 cm in the nondominant hemisphere. Another difference among surgeons is the intent to spare the superior temporal gyrus during lateral temporal neocortical resection. Many epilepsy surgeons spare the superior temporal gyrus partially or fully to decrease the risk of postoperative complications. The extent of the hippocampal resection is also controversial. Although some find it sufficient to remove the anterior 1.5 cm of the hippocampus, others extend their hippocampal resection up to 3 cm by reaching back to the posterior part of the tail. The current trend is limiting anterior temporal neocortical resection while being more aggressive with the resection of mesial temporal structures.[12,13] The size of the resection is also related to the patient's age; therefore, it probably is more reasonable, especially in pediatric epilepsy surgery, to describe the extent of temporal neocortical and hippocampal resections based on anatomical landmarks, such as sylvian end of the central sulcus and the quadrigeminal plate.

Surgical Technique

Here we will describe the anteromesial temporal lobectomy technique we use at the University of Massachusetts Medical Center. In general, our temporal lobe resection includes the anterior 3.5 cm of the temporal neocortex in the dominant hemisphere with most of the superior temporal gyrus spared, as described by Spencer et al.[31] Our resection also includes the uncus, a large part of the amygdala, and an approximately 3-cm length of the hippocampus/parahippocampus excised en bloc. The neocortical resection is extended to 5 cm in the nondominant hemisphere. Mesial structures are resected in the same manner in both dominant and nondominant hemispheres if neuropsychological assessment and Wada test results are reassuring. This technique may be modified depending on the patient's age, imaging, and electrophysiological characteristics. If there is radiologically defined dysplastic cortex or an electrophysiologically more extensive abnormality, our neocortical resection borders are redefined and may be extended further. If the epileptogenic zone is limited to a certain part of the temporal neocortex based on the invasive monitoring data, the resection may be tailored based on these data. In these cases, mesial structures may be spared, especially in some lesional epilepsy cases. Alternatively, if the radiological findings of hippocampal sclerosis are more pronounced at the hippocampal tail, then we extend our resection of the hippocampal tail much further than our standard limits. The surgical plan is extensively discussed in advance with the pediatric epilepsy team in a multidisciplinary epilepsy surgery conference, and the extent of resection is predetermined based on the aforementioned considerations. All patients receive their regular antiseizure medications on the day of surgery. We also give an age-appropriate dosage of dexamethasone after induction of anesthesia and prophylactic antibiotics before incision and for 24 hours postoperatively. We do not use mannitolours routinely.

Positioning the Patient

The patient is placed in supine position, and the head is placed in the pin head holder if the patient is older than 3 years. The horseshoe head holder is used for younger patients. A gel roll is placed under the ipsilateral shoulder, and the head is turned to the contralateral side approximately 60 degrees. The neck is slightly extended by lowering the vertex approximately 15 degrees downward, just enough to bring the zygoma to the surgeon's eyeline and to make the zygoma the most prominent point on the midline. Lastly, the occiput is tilted slightly toward the ipsilateral shoulder **(Fig. 17.1)**. This head position places the base of the temporal fossa perpendicular to the horizontal plane. The surface of the lateral temporal lobe will be in a horizontal position, and the long axis of the hippocampus will be oriented vertically relative to the surgeon with this approach. Thus, the head position will create a good alignment of the mesial structures to the surgeon's eyeline and will provide an excellent exposure to the uncus–amygdala complex, the whole length of hippocampus, and the lateral–basal temporal neocortex.

Scalp Incision

A smoothly curved, question mark–shaped scalp incision is drawn starting just above the zygoma and approximately 10 mm anterior to tragus, based on the location of palpated superficial temporal artery. Then the incision is extended upward such that it makes a smooth anterior turn at the upper point of the pinna by following the superior temporal line toward the keyhole. It ends approximately 3 to 4 cm behind the keyhole, depending on the patient's hairline (**Fig. 17.1**). Then the incision is infiltrated with 0.5% bupivacaine hydrochloride (Marcaine) diluted in 1:200.000 epinephrine solution. The superficial temporal artery is palpated and protected during the scalp incision. Some small branches of superficial temporal artery may be occasionally sacrificed, but generally the main body can be protected by dissecting and mobilizing it during the incision. Then the incision of the temporal fascia, muscle, and periosteum is also completed sharply by cutting these layers parallel to the scalp incision. Scalp, temporal fascia, muscle, and underlying periosteum are dissected subperiosteally to create a single musculocutaneous

A

B

Fig. 17.1 Head positioning of the patient. **(A)** Neck is extended by lowering the vertex approximately 15 degrees downward with a slight occipital tilt toward the ipsilateral shoulder and making the zygoma the most prominent point on the midline. **(B)** Head is turned to the contralateral side approximately 60 degrees. A question mark–shaped incision starts just above the zygoma and extends anteriorly toward the keyhole by ending just behind the hairline.

flap. The lower part of the incision is extended down to the zygoma. Having an exposure down to the zygomatic root is critical for satisfactory access to the base of the temporal fossa during the neocortical resection. The other critical point at this stage is exposure of the orbital-zygomatic ridge or the keyhole. It should be palpated, and the temporal muscle should be cut and dissected from the keyhole by retracting the scalp further and working beneath it. Then the temporal muscle is subperiosteally dissected using sharp periosteal elevators by keeping the periosteum attached to the temporal muscle as much as possible to preserve muscle innervation and vascular supply. Monopolar cautery should not be used during this dissection for the same reason. Strict adherence to this technique is critical to prevent future temporal muscle atrophy. Although application of this technique may be difficult in elderly patients, it is much easier to have an excellent subperiosteal dissection that keeps the whole periosteum intact and attached to temporal muscle in the pediatric age group. Fish hooks are then placed to reflect the musculocutaneous flap anterolaterally to expose the temporal bone widely.

Craniotomy

Three burr holes are placed with locations at the keyhole, just above the zygoma and on the superior temporal line and approximately 4 to 5 cm posterior to the burr hole on the keyhole. A free bone flap is removed after dissecting the dura with Penfield dissectors. The sphenoid ridge is removed with rongeurs to create a smooth anterior-medial bony wall. This maneuver has critical significance to have a good exposure for uncus/amygdala resection. Further bone removal is needed along the floor of the temporal fossa down to the root of the zygoma and toward the temporal tip. This will provide a comfortable access to the inferobasal neocortical region and temporal pole during the resection. Dural tack-up sutures are placed at this stage, and the epidural space at bone edges is filled with an injectable hemostatic agent, such as Surgifoam (Johnson & Johnson, Gateway, NJ, USA). Then the dura is opened C-shaped, starting from the keyhole site on frontal region and ending at temporal pole by following the craniotomy edges. The dura is folded and tacked up with 4–0 Nurolon sutures to the muscle flap over the sphenoid wing. At this stage, the exposed area in the surgical field includes the full extent of the sylvian fissure/vein, superior and middle temporal gyri, and the upper part of the inferior temporal gyrus **(Fig. 17.2).**

Neocortical Resection

The previously planned resection length of the lateral temporal neocortex is measured and marked on the cortex at this stage. The tip of the temporal pole can be seen easily seen with the help of a cortical ribbon placed on a Cottonoid over the middle temporal gyrus. A predetermined 3.5- or 5-cm resection length (depends on being on the dominant or nondominant side) from the tip of the temporal lobe is measured along the middle temporal gyrus and marked on the cortex with bipolar coagulation. The resection line starts at the medial edge of the temporal pole and turns toward the middle temporal gyrus approximately 2 cm behind the temporal tip (**Fig. 17.2**). The remaining part of the incision continues along the upper border of the middle temporal

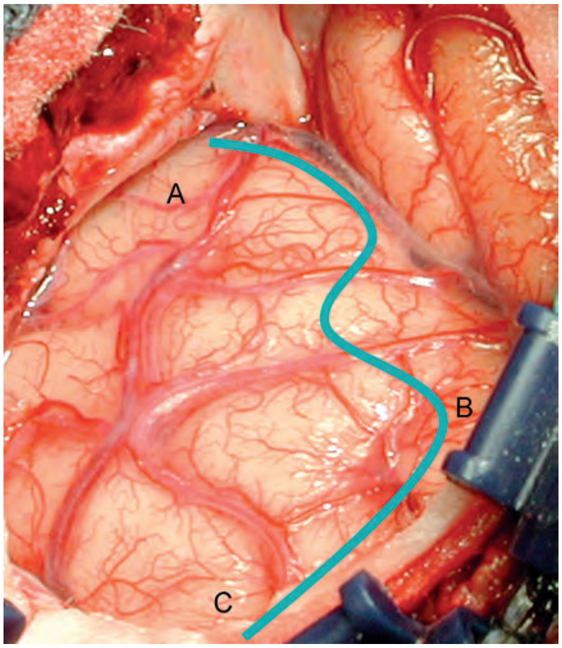


Fig. 17.2 Exposed surgical field includes anterior part of the inferior frontal gyrus, sylvian vein, and superior and middle temporal gyri. The blue line marks the surgical incision lines. First incision line (A–B) stays parallel to the sylvian fissure and second incision line (B–C) stays perpendicular to the first incision line. The first incision line starts from the most anteromedial part of the temporal pole and extends posteriorly approximately 2 cm by following the sylvian vein and staying just a few millimeters below the vein. Then the incision makes a smooth curve toward the superior temporal sulcus to preserve the superior temporal gyrus and follows the sulcus until the posterior resection line. The second incision line starts from the most posterior point of the first incision line and extends toward the floor of the temporal fossa by traversing the middle and inferior temporal gyri.

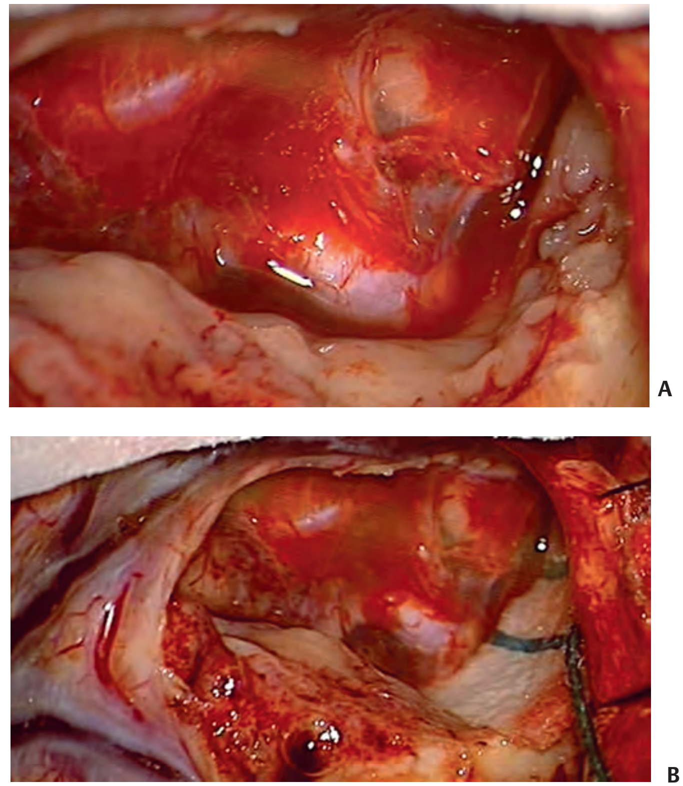


Fig. 17.3 **(A)** Temporal neocortex is subpially dissected from the sylvian fissure by keeping the pia intact to avoid any risk of injury to the middle cerebral artery (MCA) branches. **(B)** The entire temporal neocortex is removed en bloc by exposing the tentorium and mesial temporal structures.

gyrus to spare most of the superior temporal gyrus posteriorly. This resection line is marked on the pia-arachnoid of the superior and middle temporal gyri with a fine-tip bipolar coagulator staying parallel and 5 to 6 mm below the sylvian vein or superior temporal sulcus. After coagulation of the pia-arachnoid over the gyri, it is incised with microscissors throughout the length of the marked incision line. After completing the incision, the pia-arachnoid adjacent to sylvian vein is coagulated thoroughly to create an appropriate handle to hold during the subpial dissection of superior and middle temporal gyri. Then cortex is subpially dissected from pia of the sylvian fissure anteriorly and from the superior temporal sulcus posteriorly. Meticulous subpial dissection technique is used to avoid injury to the middle cerebral artery (MCA) branches in the sylvian fissure (**Fig. 17.3A**) and to protect the vascular supply of the unresected part superior temporal gyrus by leaving both pial layers of the superior temporal sulcus undisrupted on the lower bank of the superior temporal gyrus. Some bleeding is generally encountered while peeling the cortex from pia that can be easily controlled by placing Surgifoam and Cottonoid patties. We would like to remind the reader that subpial dissection is much more challenging in pediatric patients than adults because of the very thin and fragile nature of the pia at this age. Appropriate application of this technique may not be feasible in very young children.

The next critical step is finding the temporal horn. There are several approaches for this and a close review of the patient's MRI, especially coronal spoiled gradient recalled (SPGR) cuts, will be helpful to determine the best approach. The temporal horn starts approximately 3 cm behind the temporal tip, and the average distance between the surface of superior temporal gyrus and the ventricle is approximately 31 to 34 mm.[32,33] We prefer to perform our dissection to reach the temporal horn at a point on the superior temporal sulcus approximately 3.5 cm behind the tip of the temporal pole. Frequently, the T1 sulcus (superior temporal sulcus) directly brings the surgeon into the temporal horn. This can be done through an intrasulcal approach or by remaining subpial and following either the inferior wall of the superior temporal gyrus or superior wall of the middle temporal gyrus, which we prefer. The bottom of the sulcus can be easily recognized by visualizing the end of the pial bank at first. Then the ependyma can be appreciated after deepening the same incision approximately 11 to 12 mm further.[33] This distance can be measured case by case on MRI coronal cuts easily. The ependyma can be opened with Penfield #4 dissector (Codman, MA) and cerebrospinal fluid will verify the intraventricular location. If the surgeon passes the estimated distance and the temporal horn is not in sight, the best strategy is to redirect the dissection. The most common two reasons for not being able to find the ventricle are either placing the entry point of the dissection too anteriorly or directing the dissection either too medially or too laterally. At this stage, the appropriate strategy is to redirect the dissection toward the floor of the middle fossa but not medially. The dissection is then deepened toward the floor of the middle fossa until gray matter is encountered on the adjacent occipitotemporal (or fusiform) gyrus. Then the dissection is redirected again, this time medially into the white matter until temporal horn is entered. Deepening the dissection medially to search the temporal horn without taking the aforementioned strategies may easily lead the surgeon into the temporal stem and basal ganglia and may cause significant complications. Therefore redirecting the dissection intentionally too laterally initially is a much safer approach, as defined very clearly by Wen et al.[32] When we enter into the ventricle, we place a tiny cottonoid patty in it to prevent blood contamination and then subpially dissect first the superior wall of the medial temporal gyrus and then sylvian pia anteriorly to the temporal pole using microsuction in a low setting and a Penfield dissector. This subpial dissection is performed down to the ependymal level throughout the sulcus. Then the ependyma is easily opened using a bipolar coagulator, the temporal horn is unroofed all the way to its tip, and a small cotton ball is placed into the temporal horn toward the atrium to avoid intraventricular dissemination of blood products.

Several other approaches to the temporal horn exist. One is to follow the collateral sulcus. This approach is only feasible after completing the second cortical incision, which will be described in the following paragraphs. Alternatively, the temporal horn can be found after completing the resection of the anterolateral temporal lobe without locating the temporal horn. In this case, the uncus is located first by following the tentorial edge anteromedially. When removal of the uncus is completed, its posterior segment will open and expose the tip of the temporal horn automatically. Lastly, the use of a neuronavigation system to assist the localization of the temporal horn is an option.

The second cortical incision line starts from the most posterior extent of the first incision and is directed perpendicularly toward the floor of temporal fossa **(Fig. 17.2)**. The posterior line of the neocortical resection extends inferiorly traversing the superior, middle, inferior temporal, and fusiform gyri, respectively, and ends at the collateral sulcus. The temporal horn is located generally just dorsal to the base of the collateral sulcus and can be found by following the collateral sulcus pia as described previously. The average distance from the depth of the collateral sulcus to the temporal horn is 3 to 6 mm.[33] Thus, the posterior end of the first incision and superior end of the second incision lines intersect at the temporal horn. A third incision is directed to the collateral sulcus by cutting across the temporal stem and the white matter of the basal temporal lobe. This third incision disconnects the temporal neocortex from parahippocampus/hippocampus and completes the lateral neocortical temporal resection by dividing the collateral sulcus from its posterior end to the tip of the temporal horn at rhinal sulcus level. The entire lateral neocortex is removed as an en bloc specimen **(Fig. 17.3A,B)**.

Mesial Temporal Resection

For the next step, it is important to locate several anatomical landmarks and structures before proceeding to resect the mesial temporal structures. Hippocampus, fimbria, lateral ventricular sulcus, collateral eminence, choroid plexus, choroidal fissure, inferior choroidal point, and amygdala need to be fully exposed and can be distinctly recognized at this stage. The hippocampus sits over the parahippocampal gyrus

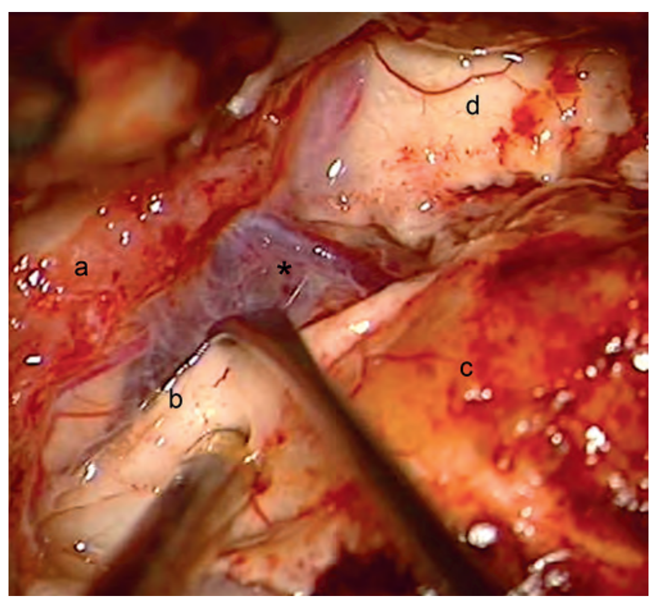
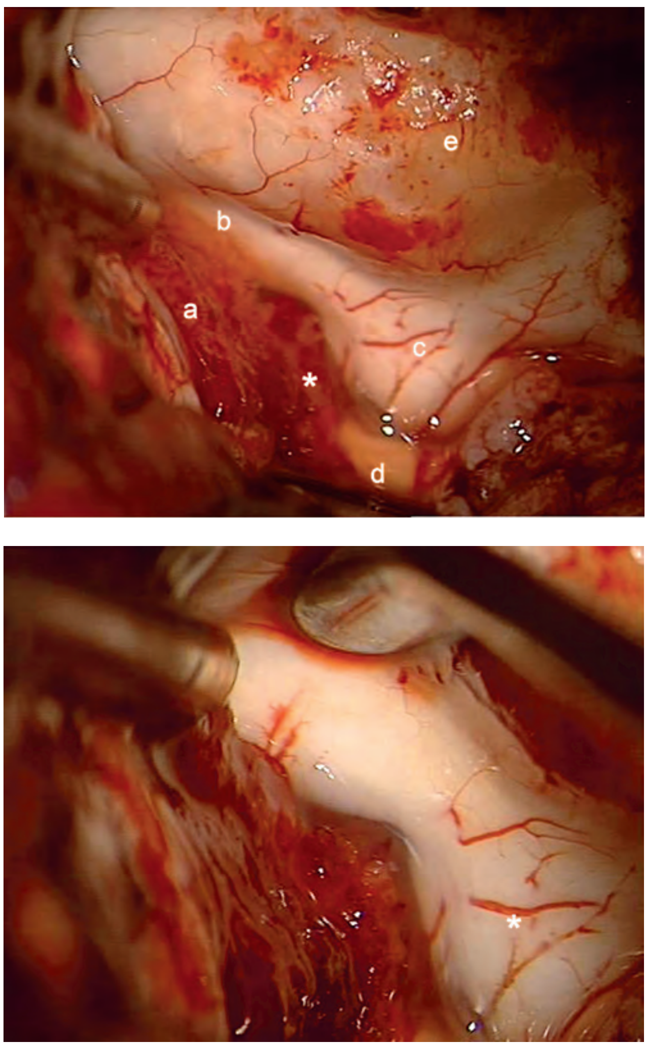


Fig. 17.4 Choroidal point (*) and anterior part of the choroidal fissure is exposed by peeling the fimbria. Note surrounding structures including choroidal plexus (a), fimbria (b), hippocampus (c), and posteromedial part of uncus (d).

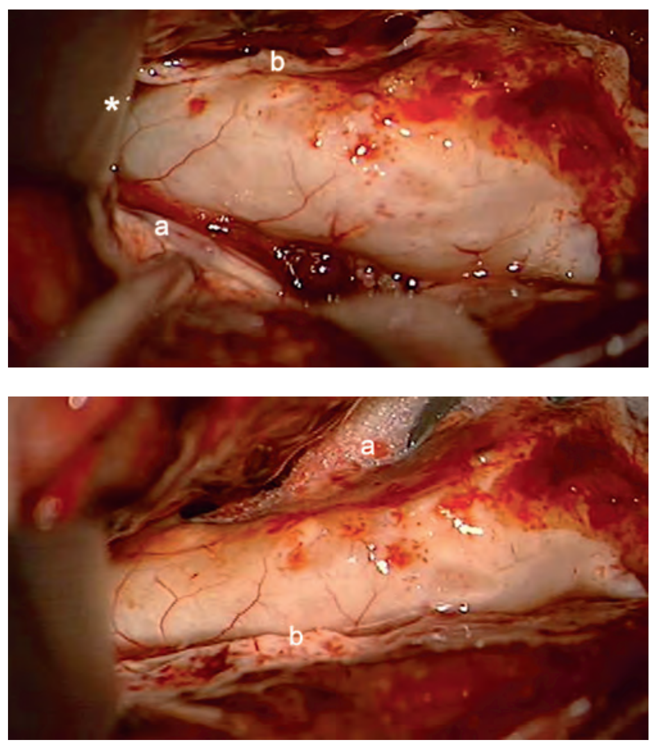
and has a short, wide head that continues with a gradually narrowing body and tail. The tail makes a backward–upward turn at the trigone level around the posterior cerebral peduncle. The anterior portion of the hippocampal head blends into the posterior uncus and amygdala (**Fig. 17.4**). The hippocampus can be easily recognized between the collateral eminence and choroidal fissure. The lateral ventricular sulcus lies between the hippocampus proper and the collateral eminence, extending anteriorly toward the amygdala–hippocampal junction. The medial border of the hippocampus is lined by the choroid plexus over the choroidal fissure and the choroidal point at the most anterior part. If the choroidal plexus is lifted gently upward and medially, the choroidal fissure and fimbria would be fully exposed **(Fig. 17.4)**. Retraction of the choroid plexus laterally over the hippocampus would expose stria terminalis. When the anterior end of the choroid plexus is pulled backward, the velum terminale and the choroidal point at the tip of the posterior uncus can be visualized **(Fig. 17.5)**. The anterior choroidal artery (AChA) runs across the ambient and crural cisterns near the choroid plexus. It pierces the arachnoid plane to supply the choroid plexus at the inferior choroidal point by giving rise to numerous branches. The anterior fimbria and stria terminalis join to form the velum terminale and create the anterior border of the choroidal fissure where the inferior choroidal point is also located (**Fig. 17.5**). The fimbria is a narrow, flat band covering the mesial border of the hippocampus. It is located just above the dentate gyrus and continues as fimbria fornix posteriorly. The temporal horn is fully unroofed to expose the most anterior part of the temporal horn that includes the bulging amygdala, posterior uncus, amygdala–hippocampal junction, and posteriorly the head and body of the hippocampus. The uncal recess is a distinct landmark that separates the head of the hippocampus from the amygdala. Better exposure of the hippocampal tail can be provided with the help of a tapering retractor ribbon **(Fig. 17.6A)**.



A

B

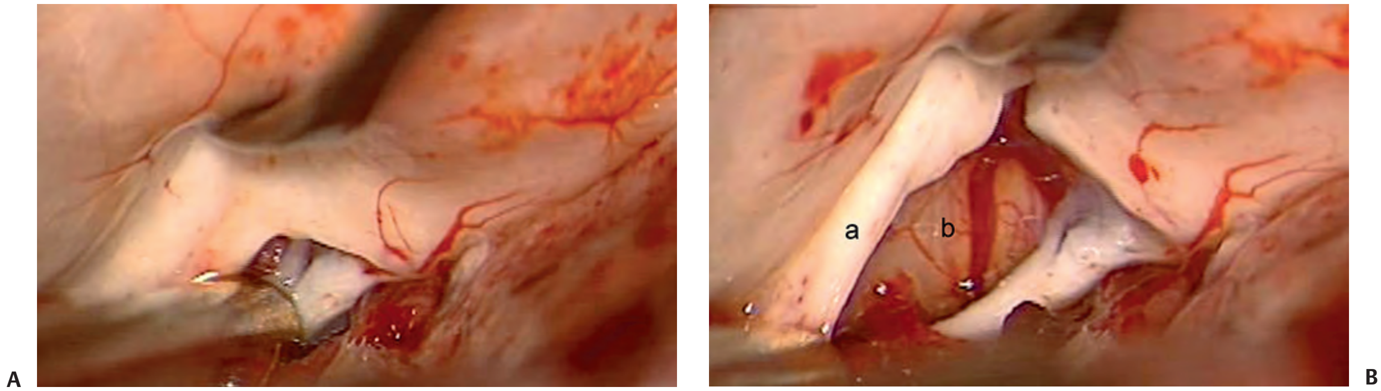
Fig. 17.5 (A) Choroidal point (*) is seen surrounded by anterior tip of choroidal plexus (a), fimbria (b), velum terminale (c), stria terminalis (d), head of hippocampus (e), and posteromedial part of uncus (f). **(B)** The anterior part of the fimbria and stria terminalis joins to form velum terminale (*).



A

B

Fig. 17.6 (A) Head and body of the hippocampus are exposed, and a retractor (*) is placed to elevate the temporal roof for further exposure of the hippocampal tail. Note choroidal sulcus (a) and surgical resection line on collateral eminence (b). **(B)** Entire hippocampus is subpially dissected as an en bloc specimen between collateral eminence (a) and fimbria (b).



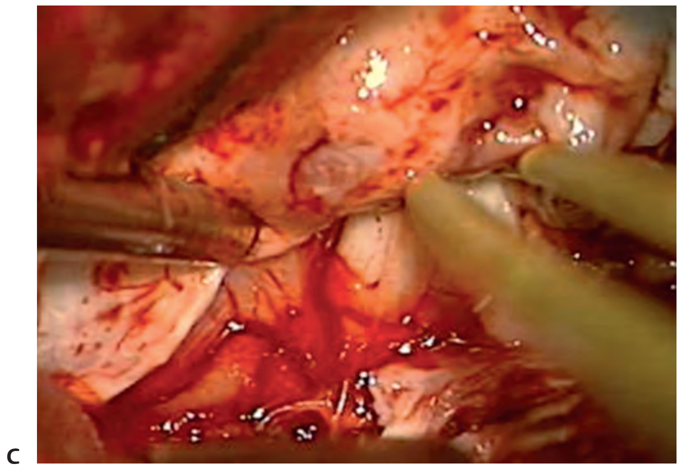


Fig. 17.7 **(A)** Fimbria is lifted with a dissector to expose the hippocampal sulcus and hippocampal arteries. **(B)** Further dissection and elevation of fimbria (a) exposes subiculum (b) and hippocampal arteries extending into hippocampal sulcus. **(C)** Subiculum and hippocampal sulcus are fully exposed, and hippocampal arteries have been coagulated.

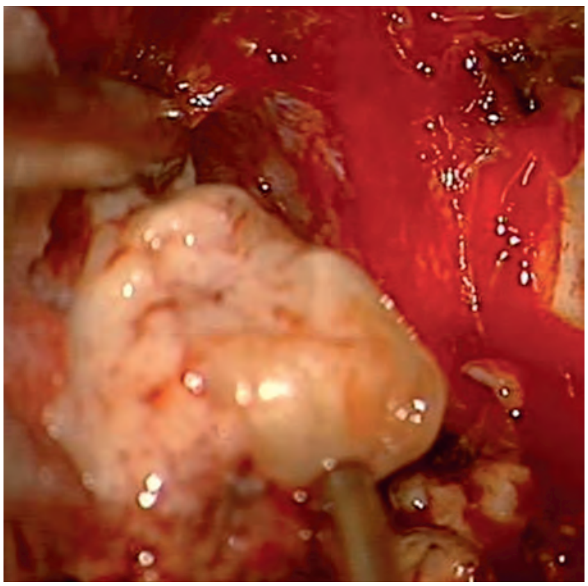
The ribbon is placed on the most posterior end of the unroofed part of the temporal horn and the remaining part of the roof is gently elevated laterally for this purpose. The hippocampal tail can be exposed with this maneuver back to the point where it makes a medial and upward turn. Obtaining this exposure is very critical for a satisfactory resection of mesial temporal structures.

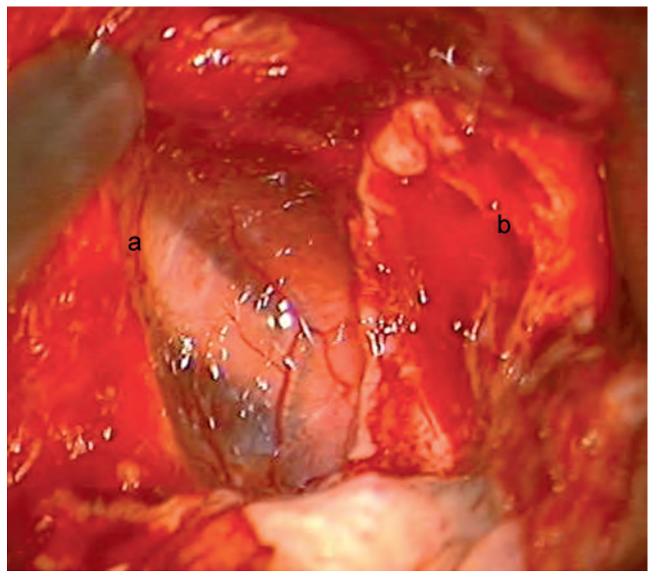
After locating the intraventricular landmarks, resection of mesial temporal structures starts with an incision on the lateral ventricular sulcus that is the demarcation line between the collateral eminence and hippocampus. The ependyma of the lateral ventricular sulcus is coagulated posteroanteriorly as an entry point to the parahippocampal gyrus. The medial pial bank of the collateral sulcus is exposed by suctioning parahippocampus intragyrally. Intragyral removal of parahippocampus is completed along the collateral eminence, starting from hippocampus proper to the amygdala–hippocampal junction. Then the lateral wall of the parahippocampus–hippocampus complex is subpially dissected by peeling it from the collateral sulcus pia using the Penfield dissectors **(Fig. 17.6B)**. Then the dissection continues mesially toward the tentorial edge until the pia along the mesial border of the parahippocampus and hippocampal sulcus is

Fig. 17.8 Hippocampus proper is removed en bloc for histological examination. Further resection of the hippocampal tail is performed with the ultrasonic aspirator.

encountered. At this stage, the subiculum of the hippocampus is peeled off toward the hippocampal sulcus. The parahippocampal gyrus lateral to this line is emptied further by suctioning it anteriorly toward the entorhinal area and uncus. At this stage, the hippocampus proper can easily be retracted laterally into the cavity created by intragyral aspiration of the parahippocampus. This maneuver provides an excellent view of the anterior end of the hippocampal sulcus. The hippocampal sulcus fans out at this junction between pes hippocampi, uncus, and anterior end of the parahippocampus **(Fig. 17.5A)**. This anatomy provides the surgeon with an excellent starting point for the dissection of hippocampal sulcus between fimbria, inferior choroidal point, and choroidal fissure. The most anterior end of the fimbria can be easily opened and peeled away from the pia of the choroidal fissure just lateral to tela choroidea. Then the fimbria can be lifted with Rhoton microdissectors (Codman, MA) at the inferior choroidal point level and underlying pia and vasculature can be exposed **(Fig. 17.4)**. The fimbria is further opened with Rhoton dissectors along its length all the way to the hippocampal tail. At this stage, the hippocampus is further retracted laterally with the suction, and the hippocampal

A





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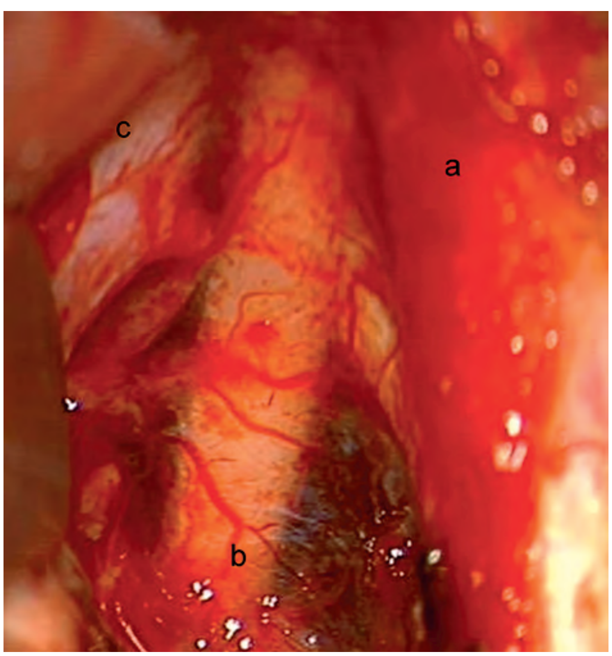

Fig. 17.9 **(A)** Uncus and amygdala are peeled from the pia are with dissectors or low-power suction. **(B)** Uncus is emptied subpially. Third nerve (a) under the pia is visible along with some residual part of amygdala (b). **(C)** After subpial removal of amygdala and uncus, edge of tentorium (a), third nerve (b), and posterior cerebral artery (PCA) (c) are visible under intact pia.

sulcus is exposed as a two-layered pial folding with several tiny arteries running between pial layers. The hippocampal sulcus is a very critical landmark in this procedure and should be fully visualized. It separates the hippocampus proper and the subiculum. The subiculum constitutes the most medial part of the parahippocampus bulging into the middle incisural space. The hippocampal arteries and arising arterioles (Uchimura arteries) are located within the hippocampal sulcus **(Fig. 17.7)**. These thin hippocampal arteries mostly form a group of 2–6 thin vessels from the AChA and medial P2 segment of posterior cerebral artery close to the free edge of the tentorium. After having a satisfactory exposure of the hippocampal sulcus, hippocampal arterioles are coagulated with fine-tipped bipolar forceps and cut with microscissors one by one (**Fig. 17.7C**). Again, it should be noted that these arteries in young pediatric patients are extremely thin and can rupture easily with manipulation. Further, the distances between the hippocampal arteries and the AChA and P2 segment are very short in pediatric patients. Therefore coagulation of hippocampal arteries should be performed carefully using very fine-tipped bipolars by staying close to hippocampus proper. Then the head of the hippocampus is fully dissected subpially from the underling pia and lifted upward and posteriorly. This maneuver provides a very nice subpial plane at the base of the whole hippocampus–parahippocampus complex. Then the hippocampal head is mobilized and lifted upward and posteriorly and the remaining parahippocampal attachments are dissected subpially using a Penfield # 4 dissector. This way the whole hippocampus and underlying part of the parahippocampus are dissected back to the hippocampal tail. Then the tail is resected with bipolar coagulation at its upward turn behind the quadrigeminal plate and the hippocampus is removed en bloc (**Fig. 17.8**).

The final step of the procedure is the resection of the amygdala while emptying the content of the anterior uncus. During this stage of the procedure, using strictly subpial dissection and showing the utmost respect to pial barriers are critical to protect the underlying vasculature, third nerve, and cerebral peduncle. The anterior amygdala blends into the uncus, and we use a microsuction with the suction regulator at the low-suction setting and Penfield dissectors to peel the uncal content from the pia below the incisura **(Fig. 17.9A)**. Ultrasonic aspirator in a low setting is also a very useful tool to empty the uncal content. After completing the resection of uncus and anterior basal amygdala, the cerebral peduncle and third nerve can be seen under the intact pia **(Fig. 17.9B)**. Although the anterior and basal borders of the amygdala are very well defined, there are no dorsomedial anatomical boundaries of the amygdala. Therefore, it is more challenging to define the dorsomedial resection borders of the amygdala. The M1 segment of the MCA, which can be seen subpially, corresponds to the anterior–superior border of the amygdala. The line extending from the anterior tip of the temporal horn to the angle of the MCA at the limen insula makes the anterior–superior border of the resection line of amygdala. The dissection at the anterior–superior border should be done very carefully because of the presence of the small MCA branches supplying the basal ganglia here. After completing the amygdala resection, the surgical cavity is re-explored and all devascularized residual cortical tissues are removed with the ultrasonic aspirator without violating the pia. At this stage, the tentorial edge, third nerve, internal cerebral artery (ICA), posterior cerebral artery (PCA), lateral edge of the midbrain between cerebral peduncle, and tectum can be seen under the pia in the ambient and crural cisterns. After hemostasis, the surgical cavity is filled with warm saline irrigation, and the dura is closed in a watertight fashion with 4–0 Nurolon sutures. The bone flap is replaced with microplates, and the temporal muscle, fascia, and galea are closed as two separate layers using 3–0 and 4–0 Vicryl sutures. The skin is closed with 4–0 Prolene sutures.

Complications

The complication rates in temporal lobe surgery series in children have been reported to be between 2 and 8%.[2,6,8] Mortality is a rare occurrence and is reported as lower than 0.5%.[34] Postoperative complications, although rare, may be devastating; using appropriate surgical techniques and extreme caution at critical stages of the surgery are essential to avoid complications. The most commonly reported complications are visual field defects, infection, stroke, manipulation or retraction hemiparesis, third nerve palsy, and language disturbances. The most common visual field defect is superior quadrantanopsia, with a reported incidence of 9% in a Benifla et al series of 126 children with TLE.[6] Benifla et al also reported a 4% incidence of homonymous hemianopia. The overall complication rate was 14.9% in Clusmann and colleagues' series, but only 2.2% had permanent deficits.[7] The incomplete or complete quadrantanopsia incidences were 28.2% and 3.8%, respectively. In a separate study by Kim et al, the rate of postoperative visual field defect was 22%.[3]

Another common complication is dysphasia, which is mostly transient. Transient dysphasia can be seen in approximately half of the dominant site temporal resections and frequently resolves within a few weeks.[35] A possible reason for this finding is the disconnection of the mesial and neocortical temporal lobe and retraction related to physiological disruption. Although rare, third and fourth nerve palsies can be seen after AMTL. Using strict subpial technique and avoiding cautery around the tentorium or high-power suction application during the uncus resection may help to avoid these complications. Partial seventh nerve palsy is another well-known complication and occurs secondary to injury of the facial nerve branches located within the temporalis fascia. This injury can be easily avoided with the technique we described here by avoiding dissection of the temporalis fascia. However, traction and monopolar cauterization in close proximity to the facial nerve may also cause facial palsy and should be taken into consideration during the craniotomy. One of the most devastating, although rare, complications in temporal lobe resection is hemiplegia. It is a well-recognized complication, with an incidence of 1 to 2%.[5] It has also been termed *manipulation hemiplegia* and frequently is related to injuries of the AChA and PCA during the resection of the mesial temporal structures. Maintaining the utmost respect to subpial technique, meticulous protection of the pia throughout the surgery, coagulation and cutting of the hippocampal arterioles strictly in hippocampal sulcus, and staying away from the main arteries (AChA or PCA) decreases the risk of injury to these vessels. MCA-related hemiplegia secondary to compression with retractors may cause this problem as well.

Outcome

The seizure control rate of temporal resections in children is different than it is in adults; the main reason is the heterogeneity of underlying pathologies. The most common neuropathological substrates in children are cortical dysplasia and neoplasms followed by gliosis and MTS.[1,6,36] Temporal lobe resection is a safe and effective surgical technique in the management of TLE with reported seizure control rates between 60 and 80%.[1,2,6–11,37,38] Seizure-free outcome rate was reported as 78% by Sinclair et al[8] in their series of 42 patients. Benifla et al[6] reported 74%, and Clusmann et al[7] reported 87% good seizure control rates (Engel Class I and II) with temporal lobe resection in 126 and 89 children, respectively. The best outcome was seen in the patients with temporal lobe neoplasms (88–92%) followed by the patients with gliosis (86%) and MTS (70%) in Benifla's series.[6] The lowest seizure control rate was seen in the patients with cortical dysplasia. Mittal et al reviewed their experience with 109 children at the Montreal Neurological Institute and reported Engel Class I and II outcomes in 86.3% of patients at more than 5 years of follow-up.[39] Jarrar et al found that the seizure-free rate in their series was 82% 5 years after surgery but decreased to 53% after 10 years.[40] Maton et al reported their experience with temporal lobe resection during early life in 20 children younger than 5 years old.[11] Sixty-five percent of the children were seizure free, and an additional 15% had more than 90% seizure reduction at a mean follow-up of 5.5 years. Smyth et al[41] reported 63.3% overall good seizure control rate (Engel I and II) in the preadolescent age group. MTS patients had a 76.9% seizure control rate, which compared favorably to cortical dysplasia and gliosis groups in this study. The Great Orman Street Hospital series reported seizure-free rates as 73% in lesional, 58% in MTS, and 33% in dual pathology groups.[5] Kim et al reported 88% seizure-free outcome in the temporal resection group of their epilepsy surgery series in children.[3]

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