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Mini Temporal Craniotomy Using Anatomical Surface Landmarks for Temporal Lobe Epilepsy: Technical Note and Clinical Outcomes

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Abstract:

Background: Patients with temporal lobe epilepsy are subjected to standard temporal lobectomy wherever indicated. This is performed using a reverse question mark flap and a standard frontotemporal craniotomy. We describe the technique of minitemporal craniotomy (3 × 3cms) for temporal lobe epilepsy (TLE) and analyze the clinical outcomes of patients operated using this approach.

Objectives: To describe the technique of minitemporal craniotomy for TLE without navigation guidance and to analyze the clinical outcomes of patients operated using this approach.

Materials and Method: This was a retrospective analysis of all consecutive TLE cases operated at our institute from 2014 to 2019, via minitemporal craniotomy, using surface landmarks only without navigation guidance. The surgical technique, indications for surgery, and their clinical outcomes were analyzed.

Results: A total number of 48 patients underwent surgery for TLE. There were no complications except three patients who had transient hemiparesis. The average duration of hospital stay was 4 days following surgery. Out of 28 patients with mesial temporal sclerosis, 22 (82%) had international league against epilepsy, Class I seizure outcome, 4 (12.5%) had Class II outcome and 2 (5.5%) had Class III outcome. 9 patients with dysembryoplastic neurectodermal tumor (DNET), 4 gangliogliomas, 2 neurocystecercosis (NCC), all had Class I outcome. Out of the five patients with MTS and associated anterior temporal focal cortical dysplasia (FCD), four (80%) had a Class I outcome, whereas one (20%) had Class II outcome.

Conclusion: Utilizing surface anatomical landmarks, minitemporal craniotomy can be performed in even peripheral centers without neuronavigation, with good cosmesis, seizure outcomes.

Key Words:

Cortical dysplasia, DNET, Drug refractory epilepsy, hippocampal sclerosis, navigation, Taylor Hughton lines

Key Message:

In this study, minitemporal craniotomy was used for the treatment of TLE due to various causes. The craniotomy was performed based on the craniometric points sans the aid of navigation. The seizure outcomes were comparable to the standard large temporal craniotomy described in the literature with better cosmesis and minimal morbidity. This procedure can be performed in centers with limited resources just based on the anatomical surface landmarks.

Temporal lobe epilepsy (TLE) is the most common cause of drug refractory epilepsy (DRE) in adult population. Cortico-amygdalo-hippocampectomy (CAH) is the standard of care for the treatment of TLE due to hippocampal sclerosis (HS). This being a functional surgery, a minimally invasive access with best functional and cosmetic outcome, becomes more appropriate. At our institution, the standard procedure of CAH is performed in cases of TLE involving the mesial structures. Over the years, we have customized the large question mark incision and thus, the temporal craniotomy, to a linear incision and minitemporal

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craniotomy, respectively. In the minimal access surgery, accuracy of the incision and the craniotomy placement is of paramount importance. Hence, neuronavigation during surgery is an invaluable tool and few studies have reported its utility for performing minitemporal craniotomy. We have been performing this procedure without using intraoperative navigation guidance but based only on the anatomical surface landmarks.[1]

Materials and Methods

All patients of drug refractory TLE undergoing minitemporal craniotomy, at our institution between 2014 and 2019, were included in this retrospective analysis. The data was retrieved from case files, Computerized Patient Record System (CPRS) and Picture Archiving and Communications System (PACS).

Surgical technique

Position

Supine with head rotation, approximately 60-70° toward the side contralateral to the surgical area, with the neck slightly extended and the head end elevated by approximately 20°. A shoulder roll underneath ipsilateral shoulder is placed to avoid twisting of the neck. The head is fixed with Mayfield clamp.

Surface marking

Sylvian fissure is marked using Taylor Houghton lines.[1] Two points, one on the outer canthus and the other on 75% point on the Nasion Inion line, are connected as line 1 [Figure 1]. Another line connecting the outer canthus and the ipsilateral tragus (line 2, Figure 1] is drawn, which approximately corresponds to the Sylvian fissure. Point ‘a’ is marked at the junction of anterior 2/3rd and posterior 1/3rd of line 2. Point ‘b’ is marked just above the Sylvian fissure. A curvilinear line joining both the points forms the incision [Figure 1].

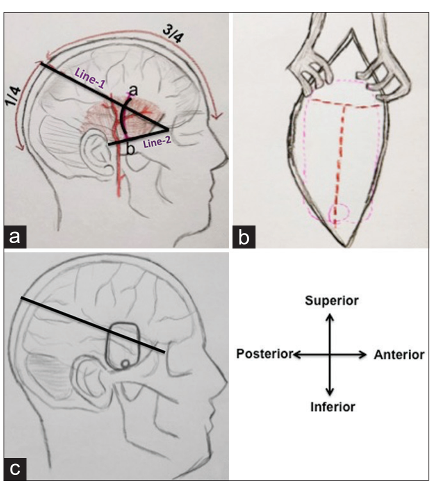

Figure 1: Sylvian fissure is marked using Taylor Houghton lines. (a) The outer canthus and the 75% point on the Nasion–Inion line are connected (line 1). The outer canthus and the ipsilateral tragus forms line 2. Point ‘a’ is marked at the junction of anterior 2/3rd and posterior 1/3rd of line 2. Point ‘b’ is marked just above the Sylvian fissure. A curvilinear line joining both the points forms the incision. (b) After skin incision, the fascia is incised in a æTæ shaped fashion. (c) A single burr hole is fashioned near the temporal base

Incision and craniotomy

The curvilinear incision is extended deep up to the temporal fascia. The temporal fascia is incised in ‘T’ shape and retracted. The temporalis muscle is split parallel to fiber orientation and swept away from the bony attachment along with the periosteum. A single burrhole is fashioned using a high-speed cutting drill at the temporal base and dura separated from the bone meticulously all around using a penfield dissector. Approximately, a 3x3 cms craniotomy is created using the craniotome. Removal of the temporal base is avoided, as it is unnecessary and leads to cosmetic deformity. Dural hitches are secured and opened in a C shape based antero-inferiorly [Figure 2]. A figure depicting the extent of exposure between the standard and minitemporal craniotomy is included for comparison [Figure 3].

Intradural procedure

Anterior temporal lobectomy

The microscope is brought in at this stage. The Sylvian fissure forms the most important landmark following which the superior (T1) and middle temporal gyri (T2) are identified. Resection limit of anterior temporal lobe is defined using a number four penfield dissector (i, e., 3-3.5 cms on the left and 3.5-4 cms on the right side). We routinely preserve the superior temporal gyrus on the dominant side. The posterior line of resection is marked using bipolar cautery.

First, the microscope is positioned so as to view perpendicular to the temporal base (tangential to brain surface) initially for resecting the lateral temporal neocortex, along the cauterized line. Once this is disconnected, the microscope is angled toward the temporal pole (parallel to the zygomatic arch) and the resection carried out in the subpial plane preserving the transparent Sylvian arachnoid and the anterior temporal lobe is removed en-block. The continuous release of cerebrospinal fluid (CSF) facilitates more brain relaxation, thereby increasing the space available for maneuvering the instruments. The next most important step is identification of the temporal horn. At this stage, the microscope is angled perpendicular to the temporal lobe and the Sylvian fissure is followed medially and posteriorly in the region deep to the middle temporal gyrus seeking the temporal horn (TH). The TH is consistently found, approximately 3-3.5 cm from the temporal pole, deep to T2.

Amygdalohippocampectomy

Once temporal horn is entered as a rule the following principles are followed [Figure 4]:

1. Avoid using diathermy in the vicinity of choroid plexus.
2. Avoid transgressing the roof of the TH.
3. En-bloc resection of the head, body and part of the hippocampal tail.
4. Resection of the Hippocampal tail up to the level where it turns into the atrium of the lateral ventricle
5. Structures lateral to the choroid plexus along with the amygdala, which constitute the mesial structures, should be removed completely.

The amygdala forms the anterior and superior part of the TH and is divided into two parts: the temporal (Principal) part and the extended amygdala. The temporal amygdala is routinely removed piecemeal, whereas the extended amygdala blends superiorly with the basal nuclei and is preserved.

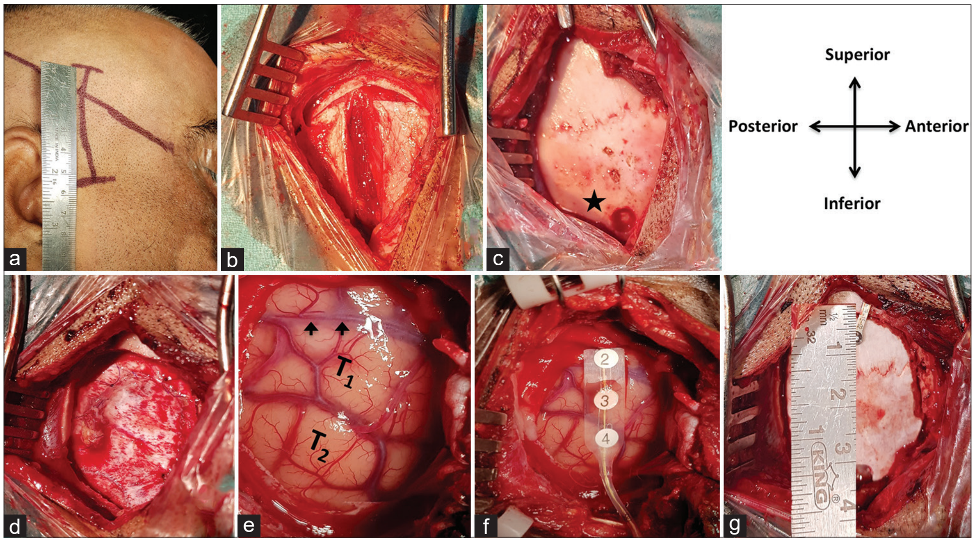

Figure 2: (a-d) After a linear skin incision of approx. 5 cm, æTæ shaped fascial incision made, 3 × 3 cms craniotomy fashioned with a single burr hole at the base (star). æCæ dural opening made based inferiorly. (e and f) Note the Sylvian fissure, the superior (T1) and inferior (T2) temporal gyri with electrocortical grid. (g) craniotomy closure

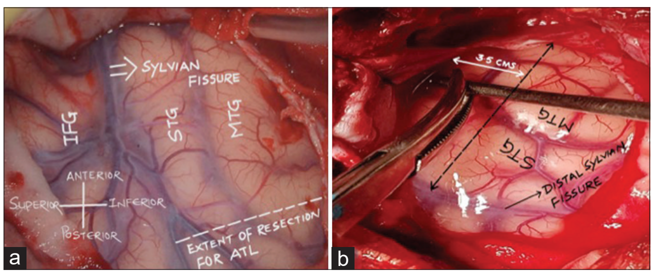

Figure 3: Comparing the extent of exposure: (a) standard temporal craniotomy centered on the Sylvian fissure with inferior frontal, superior, and inferior temporal gyri visible. The proximal and the distal Sylvian fissure along with the temporal pole is also seen. (b) Minitemporal craniotomy with distal Sylvian fissure, superior and middle temporal gyri visible. Note the temporal pole is not visible. Hence, to perform anterior temporal lobe (ATL) resection (broken black line), the microscope should be angled parallel to the zygomatic arch, together with the release of the CSF.

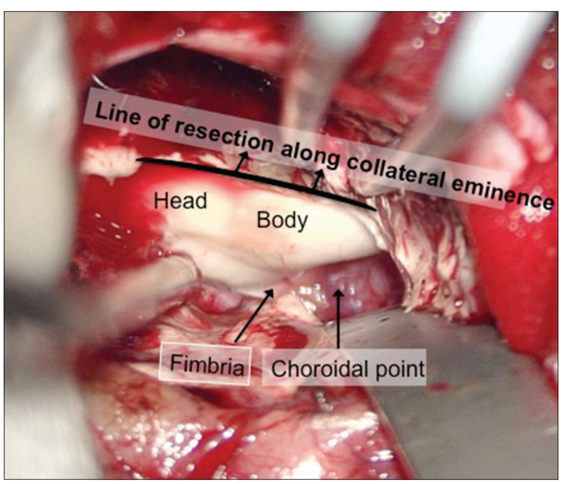

Figure 4: Landmarks within the temporal horn: Anterior most part of choroid plexus (choroidal point). Hippocampus (head and body with fimbria). Note the structures lateral to the choroid plexus should be resected

After entering into the temporal horn, the choroidal point and the collateral eminence are identified. The roof of the temporal horn is gently elevated with the help of a leyla retractor, so as to expose the choroid plexus. Hippocampal resection is begun in a stepwise manner:

1) Lateral disconnection is begun along the lateral ventricular sulcus, which separates the hippocampus from the collateral eminence. The resection is carried out till the basal arachnoid by aspirating through the parahippocampal gyrus.
2) Medially, the hippocampus is lifted off the arachnoid fold forming the hippocampal fissure and the hippocampal vessels are sectioned close to the hippocampus at the fimbrio-dentate sulcus [Figures 5 and 6].
3) At this stage, the microscope is angled posteriorly along the tail of the hippocampus, which is disconnected posteriorly. The head, body, and part of the tail of the hippocampus are resected en-block. The remaining tail is resected in a piecemeal fashion till it turns into the atrium of the lateral ventricle, which corresponds to the level of the collicular plate.

Results

A total number of 48 patients underwent surgery for MTS using minitemporal craniotomy between 2014 and 2019 at our institute. There were 28 cases of mesial temporal sclerosis (MTS), 9 dysembryoplastic neurectodermal tumor (DNET), 4 gangliogliomas, 2 neurocystecercosis (NCC) and 5 MTS with associated anterior temporal focal cortical dysplasia (FCD) [Table 1]. There have been no cases of temporalis muscle atrophy, CSF leak, visible bone defect, or pseudomeningocele formation. Three patients had transient hemiparesis, which improved over a couple of days. Post-operative magnetic resonance imaging showed satisfactory resection of the structures.

Discussion

Temporal lobe epilepsy constitutes the most common form of DRE in adults. Surgery offers the best chance of seizure freedom in these cases. Current literature clearly expresses the best seizure outcomes following surgery.[2-5] The surgical

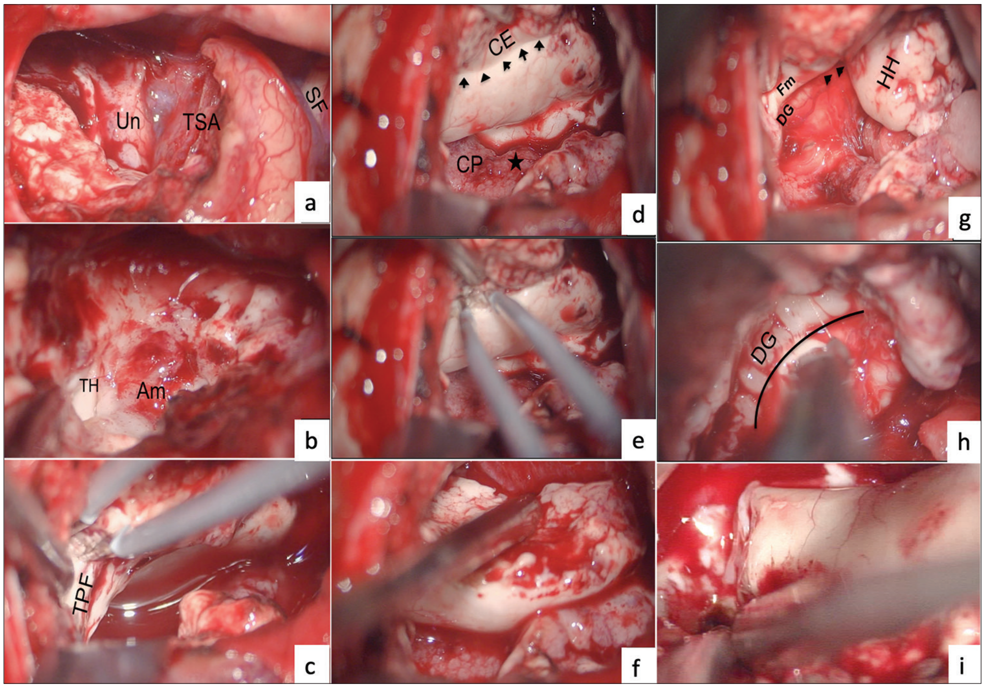

Figure 5: Step-wise dissection: (a) After anterior temporal lobectomy, the temporal Sylvian arachnoid (TSA) is preserved and uncus (Un) is seen in the depth. (b and c) The temporal horn (TH) exposed by following the Sylvan arachnoid posteriorly and resecting part of temporal amygdala (Am), the tapetal fibers are cut to openup the TH. (d-f) lateral disconnection done through lateral ventricular sulcus (arrows) and collateral eminence (CE). (g-i) Medially, the arachnoidal fold is peeled off fimbrio (Fm)-Dentate Gyrus (DG) sulcus. Posteriorly the hippocampal tail is cut

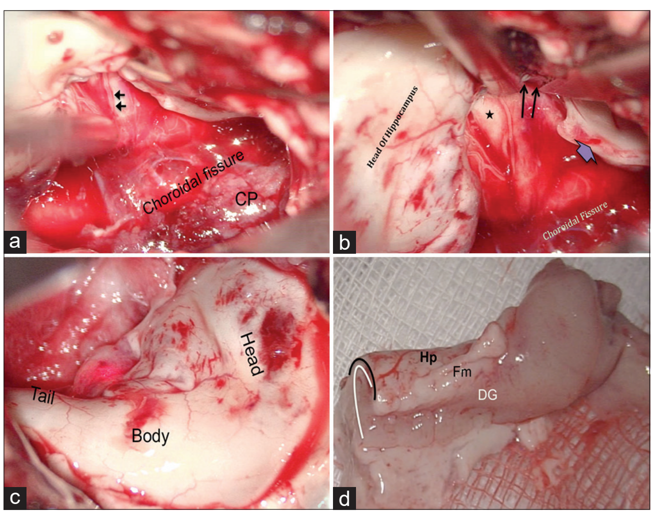

Figure 6: (a) Magnified view of hippocampal arteries (arrows), (b) hippocampal fissure or the fimrio-dentate sulcus (arrows) and the subiculum (asterix) seen through the transparent arachnoid. (c) Ventricular surface of enbloc resected hippocampal specimen. (d) Cisternal surface of hippocampal specimen, note the interlocking of the dentate gyrus (DG) and the hippocampus (Hp) with fimbria (Fm)

procedures used for the treatment of MTS include CAH and SAH. Debate still exists on the superiority of type of the surgical procedure. In some large series, there is a trend toward better seizure-free outcomes following CAH compared to SAH. Similarly, some of the studies favor SAH with regards to better neuropsychiatric sequelae. Most of the major series published in the literature, conclude no difference in the outcomes, with regards to seizure freedom and cognitive symptoms, following both the procedures.[6] However, there is no Class-I evidence till date to prove the supremacy of one technique over the other.

Table 1: Etiology of temporal lobe epilepsy

Diagnosis	Right (N)	Left (N)	Total (N)
MTS	13	15	28
DNET	5	4	9
Ganglioglioma	3	1	4
NCC	1	1	1
MTS + FCD	2	3	5
Overall			48

A study conducted at our institute on the patterns of neuronal excitation of the surgically resected specimen in patients with MTS found, spontaneous EPSPs of high frequency, and amplitude in the pyramidal neurons from both the hippocampus and the anterior temporal lobe specimen. Thus, suggesting the mechanism of increased excitability in the hippocampal and the anterior temporal region of patients with HS distinctly. Therefore, implying two independent resting-state networks at the cellular level.[7-9]

With growing experience and better understanding of the microsurgical anatomy, there is a paradigm shift toward minimal access neurosurgery. This becomes more appropriate in the context of functional surgeries like epilepsy surgery. The advancements in the minimally invasive neurosurgery have been possible with technological progress in the field of stereotactic techniques. Very few studies have utilized mini-temporal craniotomy for performing surgery in cases suffering from drug refractory TLE. The available literature for performing this procedure emphasizes on the use of intraoperative navigation for accurate localization of the skin incision and craniotomy.[10-12]

All the studies describing minitemporal craniotomies for TLE have utilized navigation guidance all through the surgery. Two of these studies described the performance of SAH[10,11] and only one group executed the standard temporal lobectomy.[12] Although, navigation is very useful tool for intraoperative guidance, a thorough knowledge of the temporal lobe anatomy would accomplish a successful surgery. Otaibi *et al.* compared patients undergoing minitemporal craniotomy with those of standard temporal craniotomy for CAH. They showed the advantages of minicraniotomy in the form of better cosmetic outcomes, lesser postoperative hospital stay, less blood loss, and seizure outcomes comparable to the standard temporal craniotomy patients.[9]

In our experience, we have been performing minitemporal craniotomy of approximately 3 cm dimension using a linear scalp incision of approximately 5 cm. The Sylvian fissure forms the most important landmark for the resection of the temporal lobe. Hence, it becomes imperative to know the location of Sylvian fissure prior to the placement of the skin incision and fashioning the craniotomy accordingly. In the initial five cases, after marking the Sylvian fissure using the standard Taylor Haughton lines, we used navigation (Medtronic stealth station-6) guidance to confirm the location of the fissure already marked. In all the cases the surface marking overlapped with that of the navigation [Figure 7]. Now, we perform this surgery without the aid of navigation, based only on the surface landmarks. The skin incision and hence the craniotomy is marked so as to just expose the Sylvian fissure, as already described in the technical details. The rotation of the head (approximately 60-70°) to the contralateral side of surgery brings the hippocampus to lie along the line of vision, posteriorly.

Removal of the anterior temporal lobe along with the accompanying CSF egress from the cisterns provides ample space for manipulating the instruments. The maneuvering of the microscope is the key to perform this procedure, as already described in the technical description. Four key angles of the microscope are necessary to perform this procedure; 1) First, the microscopic vision perpendicular to the temporal base 2) Second, parallel to the zygomatic arch, toward the temporal tip, which lies in the anterior and inferior direction. 3) Third, perpendicular to the middle temporal gyrus, after ATL, so as to identify the temporal horn. 4) Fourth, the microscope is angled posteriorly along the hippocampal tail toward the atrium of the lateral ventricle.

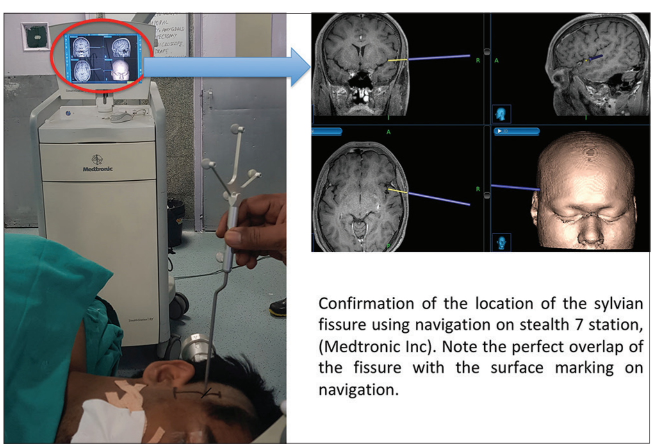

Figure 7: Note the perfect overlap of the Sylvian fissure marked using surface landmarks and the navigation which was used in the initial few cases for confirmation

Surgical outcomes

We have performed minitemporal craniotomy in patients with MTS, DNETs, NCC, and gangliogliomas involving mesial temporal structures [Table 1]. This procedure can also be undertaken in patients of MTS with focal cortical dysplasia (FCD) involving temporal pole/anterior temporal lobe.

There were no patients with wound related complications, minimal scar formation was noted as subcuticular sutures were used to close the wound, no patients complained of temporalis atrophy although quantitative analysis was not performed. Seizure outcomes were comparable to those quoted in the literature following standard temporal lobectomies.

Table 2: Seizure outcomes as per diagnosis

Diagnosis	Seizure outcome (ILAE) at 1 year follow-up		
	Class 1 *n* (%)	Class 2 *n* (%)	Class 3 *n* (%)
MTS	22 (82%)	4 (12.5%)	2 (5.5%)
DNET	9 (100%)		
Ganglioglioma	4 (100%)		
NCC	2 (100%)		
MTS + FCD	4 (80%)	1 (20%)	

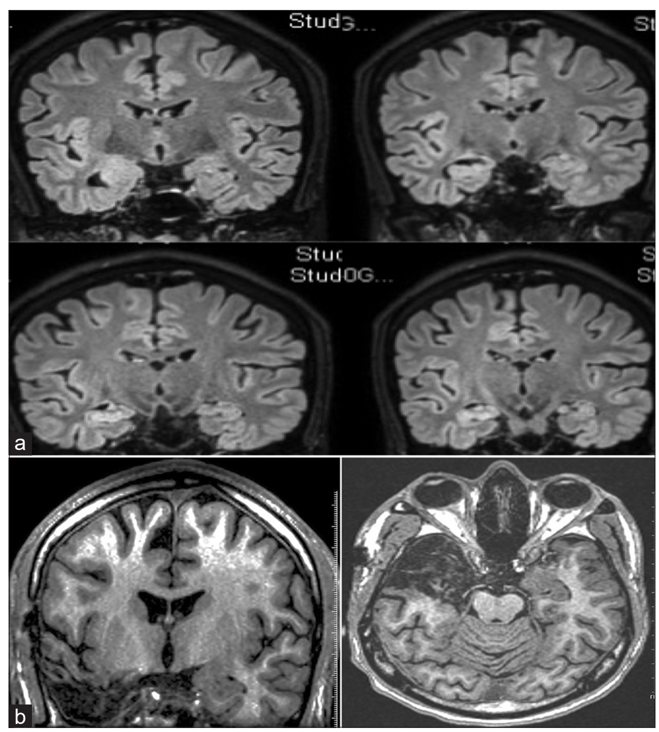

Figure 8: (a) Preoperative coronal FLAIR MRI Images showing right hippocampal sclerosis. (b) Postoperative T1W MRI images showing standard temporal lobectomy

Seizure outcomes as per International League Against Epilepsy Classification (ILAE) are mentioned in Table 2. The average duration of hospital stay was 4 days following surgery.[13]

Postoperative imaging

Routine postoperative computed tomography (CT) brain was performed in all the patients which showed adequate resection of the ATL and the mesial structures. The hippocampal tail resection was seen till the level of the colliculi, as evidenced on the CT scan by presence of blood and air at that level. Postoperative MRI performed in few patients, depicted resection of hippocampal tail till the collicular level [Figure 8].

FCDs involving entire temporal lobe, DNETs, and gangliogliomas involving posterior temporal neocortex may not be accessible for resection and are the limitations of this technique. A standard temporal craniotomy should be resorted to tackle these situations. The exposure achieved using minitemporal craniotomy was adequate to perform CAH, although we have not compared with the standard craniotomy. Further study comparing the exposure achieved during surgery and the extent of hippocampal resection along with the results following both the craniotomies may be planned to validate this procedure.

Conclusion

Minitemporal craniotomy is an elegant technique for performing standard temporal lobectomy in patients of drug refractory TLE. Utilizing surface anatomical landmarks, this procedure can be performed with ease even in resource-limited settings, without navigation guidance with good cosmesis, seizure outcomes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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