The Anterior Trans–Superior Temporal Gyrus Approach for Selective Amygdalohippocampectomy

Emmanuel Costa[1], *Vincent Joris*[1], *Geraldo Vaz*[1], *Susana Ferrao Santos*[2], *Riëm El-Tahry*[2], *Thierry Duprez*[3], *Christian Raftopoulos*[1]

■ BACKGROUND: **Different surgical approaches have been described for selective amygdalohippocampectomy in patients with pharmacoresistant temporal lobe epilepsy. The aim of this study was to report the results of the innovative anterior trans–superior temporal gyrus approach in a single-center series.**

■ METHODS: **Patients' characteristics, postoperative outcomes, and complications were reviewed in a series of 8 consecutive patients with temporal lobe epilepsy operated on using the anterior trans–superior temporal gyrus approach between November 2015 and April 2017.**

■ RESULTS: **Over a mean 2.5-year follow-up, 7 of 8 patients (87.5%) remained seizure-free (Engel class I). Only 1 patient (12.5%) was not cured (Engel class III) with no clear explanation for treatment failure. Mean operative time was 237 minutes, which was 80 minutes shorter compared with the classic transsylvian approach. No perioperative deaths were recorded and there were no visual field defects or visual acuity impairments secondary to the approach. One patient experienced a left posterior thalamocapsular stroke.**

■ CONCLUSIONS: **The anterior trans–superior temporal gyrus approach is feasible, fast, and safe for selective amygdalohippocampectomy in patients with drug-refractory temporal lobe epilepsy. This approach allows preservation of the optic radiation but cuts part of the uncinate fasciculus and potentially the anterior aspect of the anterior bundle of the middle longitudinal fasciculus.**

INTRODUCTION

Functional surgery for pharmacoresistant temporal lobe epilepsy (TLE) is a growing treatment modality that results in better seizure control and improved quality of life. Anterior temporal lobectomy is a standard surgical approach for TLE cases, but its drawbacks include visual and memory deficits. With the availability of refined neurophysiological work-up techniques, epileptogenic foci can be more precisely delineated, allowing more selective surgical resections. The hippocampus, amygdala, and parahippocampal gyrus are the most frequently involved anatomical structures in TLE, and involvement of lateral temporal cortex in epileptogenesis is sometimes absent. In those cases, selective amygdalohippocampectomy (SeAH) often appears as the best option mainly to reduce the impact on visual function. Different approaches have been described to perform selective resection, including the following: 1) the transsylvian approach described by Yasargil et al.,[1] which reduces the transcortical route by opening the sylvian fissure; 2) the transcortical approach through the middle temporal gyrus initially described by Niemeyer[2] and further developed by other authors[3-5]; and more recently a subtemporal approach described by Hori et al.[6] and Little et al.,[7] which avoids any resection of the lateral temporal cortex. In this study, we investigated the benefit/risk balance of

Key words
- Amygdalohippocampectomy
- Epilepsy
- Gyrus
- Neurosurgery
- Superior
- Temporal

Abbreviations and Acronyms
SeAH: Selective amygdalohippocampectomy
STG: Superior temporal gyrus
TLE: Temporal lobe epilepsy
Trans-MTG: Trans–middle temporal gyrus
Trans-STG: Trans–superior temporal gyrus
UF: Uncinate fasciculus

From the Departments of [1]Neurosurgery, [2]Neurology, and [3]Radiology and Medical Imaging, Saint-Luc Academic Hospital, Université Catholique de Louvain, Brussels, Belgium

To whom correspondence should be addressed: Christian Raftopoulos, M.D., Ph.D.
[E-mail: Christian.raftopoulos@uclouvain.be]

Emmanuel Costa and Vincent Joris are co–first authors.

Citation: World Neurosurg. (2021).
https://doi.org/10.1016/j.wneu.2021.12.034

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

the trans–superior temporal gyrus (trans-STG) approach to assess whether the technique had similar results as the other approaches.

MATERIALS AND METHODS

Patient Selection

We performed a retrospective review of all patients operated on for TLE (N = 44) from January 2013 to December 2018. This retrospective review of patient data did not require specific patient consent, as an institutional consent is signed by each patient for further data use in retrospective review. An ethical or institution review board approval was not sought per our institution guidelines for retrospective observational studies. We first selected patients who underwent SeAH without any additional procedure, such as temporal disconnection ($n = 18$), and ultimately included in the analysis only the patient subset ($n = 8$ [3 females and 5 males) operated on through the anterior trans-T1 approach by the same surgeon (C.R.), the first procedure having been performed in November 2015.

Clinical Work-Up

All patients underwent a comprehensive neurological and epileptological assessment, including three-dimensional brain magnetic resonance imaging, ^{18}F-labeled fluorodeoxyglucose positron emission tomography, neuropsychological work-up, and 1-week video electroencephalogram. All patients' charts were discussed at a multidisciplinary meeting including an epileptologist, neurosurgeon, neuropsychologist, and neuroradiologist. Complementary invasive electroencephalogram recording and/or Wada test was performed if all results were not unequivocally consistent with the seizure semiology. When the indication for SeAH was established, patients underwent a preoperative visual field examination using routine automated Humphrey field evaluation and/or manual Goldmann field if needed. The day before surgery, preoperative magnetic resonance imaging including contrast-enhanced three-dimensional T1-weighted morphological imaging and 20-direction diffusion tensor imaging was performed for surgical planning and tractography. At 3 months after surgery, each patient had follow-up brain magnetic resonance imaging, neuropsychological assessment, and visual field evaluation.

Surgical Technique

Each intervention was performed under neuronavigation including tractography (Curve Navigation; Brainlab AG, Munich, Germany) by the senior author (C.R.). We used a minimal hair cut (1-cm width) and a temporofrontal curvilinear incision to perform a pterional craniotomy.

The purpose of this approach is to speed up the access to the piriform lobe and the proper hippocampus and to minimize the risk of injury to the optic radiation. To reach these goals, we penetrate the superior temporal gyrus (STG) at the junction between Brodmann area 38 (the temporopolar area) and Brodmann area 22 just in front of the inferior virtual projection of the ascending frontal sulcus on the STG through a corticotomy of approximately 15 mm. The approach then descends beneath the pia mater along the insular lobe to reach the limen insulae at the tip of the circular sulcus. During this fast descent, some of the middle cerebral artery branches protected by the pia can be seen.

From that point, we penetrate the temporal stem through the uncinate fasciculus (UF) and the posterior division of the anterior commissure in front of the inferior fronto-occipital fasciculus to arrive at the anterior tip of the temporal horn and the amygdala. A temporary hemostatic sponge (Gelfoam; Pfizer Inc., New York, New York, USA) usually is left in the temporal horn to avoid blood contamination in the ventricular system and is removed when the resection has been completed.

We resect the amygdala leaving a superomedial residue to avoid trespassing into the basal ganglia and start the resection of the proper hippocampus and parahippocampal gyrus keeping the rhinal and collateral sulci as the lateral frontier for the resection and the hippocampal fissure as the central axis of the resection. The medial frontier is the fimbria, which is followed up to the subsplenial area and then disconnected. That limbic resection can be performed through the nearly anterior-posterior axis of our trans-STG approach (Figures 1 and 2).

Cognitive Evaluation

A standardized preoperative and postoperative neuropsychological protocol was applied in each patient by a clinical neuropsychologist to assess changes attributable to the surgical intervention. Testing included Wechsler Adult Intelligence Scale, Fourth Edition for intellectual function, Mini-Mental State Examination for spatiotemporal orientation, and Wechsler Adult Intelligence Scale, Third Edition and Spatial Ampen for short-term memory. Long-term memory was tested using the Rappel Libre à 15 items avec remémoration sélective (in USA, equivalent to California Verbal Learning Test) (verbal memory) and Baddeley test (visual memory). Executive functions were assessed by the Stroop test (inhibition) and the Trail Making Test (flexibility). Language functions were investigated using the Lexis test (denomination) and the verbal fluency test.

RESULTS

Eight consecutive patients (3 females and 5 males) with mesiotemporal epilepsy were included in the analysis. The mean age at the time of surgery was 41.7 years (range, 19.9–53.2 years). The mean duration of epilepsy was 12.8 years (range, 3–22 years) with a mean frequency of seizure of 18.25 seizures per month (range, 1–105/month). Mean postoperative follow-up was 2.5 years (range, 0.6–4 years).

The preoperative work-up demonstrated unilateral mesiotemporal sclerosis on neuroimaging in all cases together with electroclinical and metabolic features suggesting mesiotemporal epilepsy only. There was no suspicion of associated lateral temporal epilepsy in any of the patients. One patient underwent an invasive electroencephalogram a few months before the surgery to confirm the absence of other epileptogenic foci. Preoperative visual field testing was normal in all patients except one with unspecific left upper paracentral deficit. SeAH was indicated after discussion of each case at the multidisciplinary meeting and explained to the patients, all of whom consented to the surgery. Mesiotemporal sclerosis was on the left side in 3 patients and on the right side in 5 patients. These data are summarized in Table 1.

The mean operative time was 237 minutes (range, 230–250 minutes). No perioperative complications were reported. One

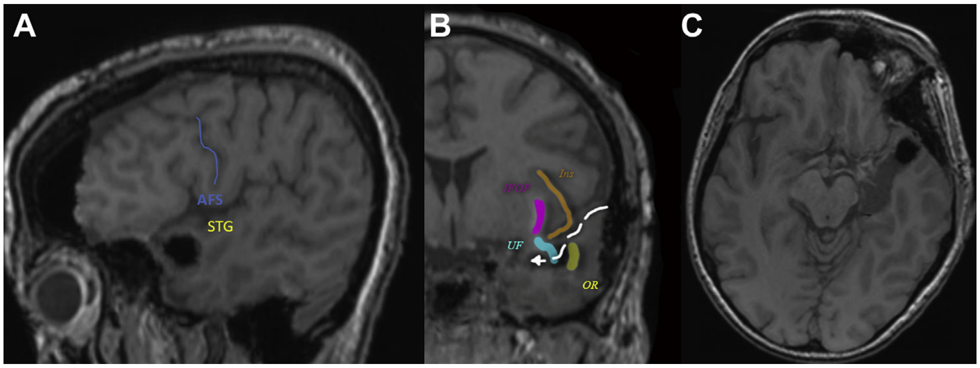

Figure 1. (**A**) Sagittal view. Entry point on the superior temporal gyrus in front of the inferior virtual projection of the ascending frontal sulcus (*blue line*) on the superior temporal gyrus. (**B**) Frontal view. The trajectory (*white broken line*) descends beneath the pia mater along the insular lobe (*orange line*) to reach the limen insulae at the tip of the circular sulcus then the temporal stem is penetrated through the uncinate fasciculus (*aqua line*). This trajectory is more anterior, superior and medial to the optic radiation (*yellow line*) as well as inferior to the inferior fronto-occipital fasciculus (*fuchsia line*). (**C**) Axial view of the limbic resection through the nearly anterior-posterior axis of our trans–superior temporal gyrus Brodmann area 38 approach. AFS, ascending frontal sulcus; STG, superior temporal gyrus; Ins, insular lobe; IFOF, inferior fronto-occipital fasciculus; UF, uncinate fasciculus; OR, optic radiation.

patient developed a temporary pseudomeningocele, which completely resolved with conservative treatment. Another 51-year-old, right-handed patient who underwent a left-sided mesiotemporal sclerosis experienced a left posterior thalamocapsular ischemic stroke (**Figure 3**) resulting in right-sided hemianopia and hemiparesis. None of the other patients experienced visual field or visual acuity impairment. Lastly, a 53-year-old, right-handed patient operated on the right side developed difficulties in naming persons in the month after the surgery from which she had not fully recovered at latest follow-up visit 3 years after surgery. For this patient, the neuropsychological assessment showed a discreet degradation of visual memory, which is now very weak; a discreet degradation of working memory, which is now weak; but preservation of verbal memory. The most important impairment was mental flexibility.

Of patients, 7 were Engel class I (seizure-free) at the last follow-up, and 1 was Engel class III (significant improvements). Histopathological examination of resected specimens confirmed hippocampal sclerosis in all but 1 patient, in whom gliosis and angiosclerosis were found. The surgical outcomes are summarized in **Table 2**.

DISCUSSION

We present a series of 8 patients with mesiotemporal sclerosis and confirmed medial temporal epilepsy operated through a anterior trans-STG SeHA. The majority of patients (7/8) achieved Engel class I after surgery, and 1 patient was Engel class III. We reported 1 transient complication (pseudomeningocele) and 2 permanent complications (1 thalamocapsular stroke and 1 visual and working memory decline associated with mild prosopagnosia).

SeHA has been widely accepted in cases of pharmacoresistant mesiotemporal epilepsy,[8] in which the epileptic focus is limited to the mesiotemporal structure and the work-up does not show any neocortical activity. Over the years, different approaches have been described with advantages and weaknesses: the main approaches are transsylvian, transcortical (i.e., transtemporal), and subtemporal. Authors have also described a paramedian supracerebellar-transtentorial approach[9] and an endoscopic endonasal approach[10] (performed only on cadaver), but those do not seem to have widely spread.

A few years ago, to reduce the dissection time and risk of vascular lesion, the senior author (C.R.) decided to switch from a trans-sylvian approach to an anterior trans-STG approach. The anterior trans-STG approach was favored over the trans–middle temporal gyrus (trans-MTG) to reduce lesions to the optic radiation. The trans-STG approach was described by Rougier et al. in 1992.[11] A slightly comparable approach through the superior temporal sulcus was described by Olivier in 1997,[12] but this author changed to a trans-MTG later.[13] Mathon and Clemenceau[14] described the same approach through a keyhole approach, but they did not review the safety and outcome. In this series, we retrospectively reviewed the 8 first cases operated on with this approach and described our technique.

From an anatomical standpoint, the variation in approaches will mainly be the white matter tracts transected and the vascular structures preserved. Indeed, the final goal always remains the same and seems to be achievable in every approach: resection of amygdala and hippocampus. This is shown with our functional outcomes, which are good and comparable to the reported literature. At 2.5 years, we have 7 patients (87.5%) with Engel class I and 1 patient (12.5%) with Engel class III, which is well within the range of reported values of good outcome (82%–93.1% of Engel

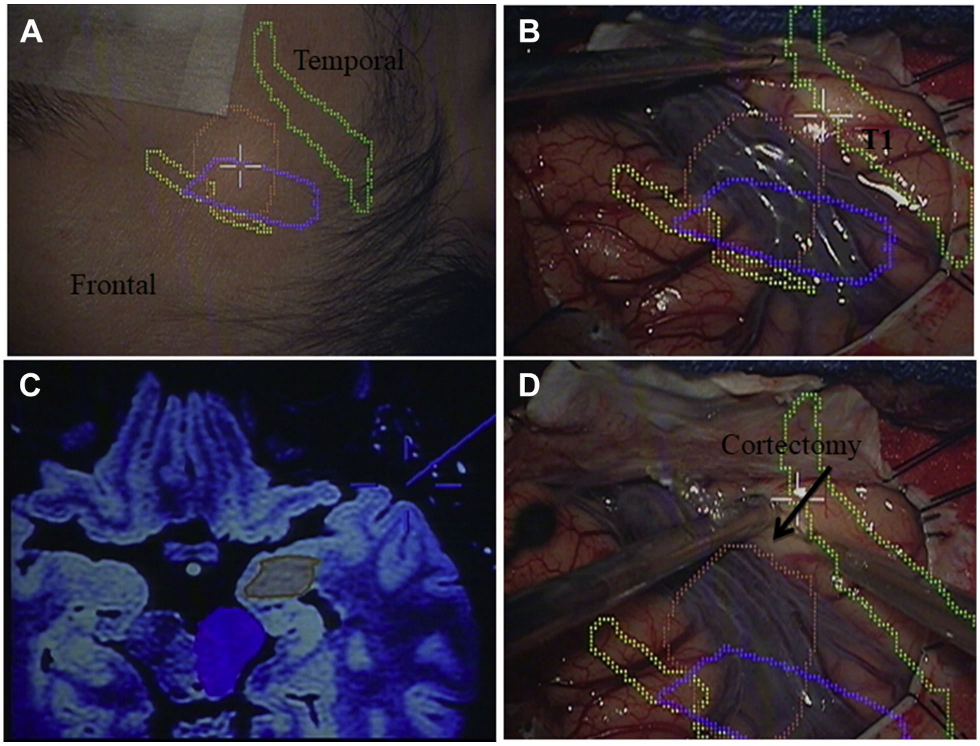

Figure 2. (**A**–**D**) Intraoperative views of the anterior trans–superior temporal gyrus selective amygdalohippocampectomy in patient 1. Augmented-reality microscopic view showing an overlay on the patient's skin (**A**) and similar view after dura opening (**B**) and cortectomy (**D**). (**C**) Corresponding neuronavigation axial view. *Yellow dotted lines*, optic tract; *red dotted lines*, amygdala; *blue dotted lines*, mesencephalon; *green dotted lines*, tractography of the optic radiation.

Table 1. Clinical Characteristics of Patients with Selective Amygdalohippocampectomy by Anterior Trans–Superior Temporal Gyrus Approach Between November 2015 and April 2017

Patient	Age (years)/Sex	Seizure Duration (years)	Number of Seizures (per month)	Pre-op Visual Field	iEEG	Operative Side
1	53/F	6	10	Normal	–	Right
2	52/M	15	1	Normal	–	Right
3	19/M	5	3	Normal	+	Right
4	22/F	6	105	Deficit*	–	Left
5	37/M	22	10	Normal	–	Right
6	51/F	20	6	Normal	–	Left
7	51/M	17	5	Normal	–	Left
8	44/M	15	6	Normal	–	Right
Average	41	12.75	18.5			

Pre-Op, preoperative; iEEG, invasive electroencephalogram; F, female; M, male.
*Left upper paracentral.

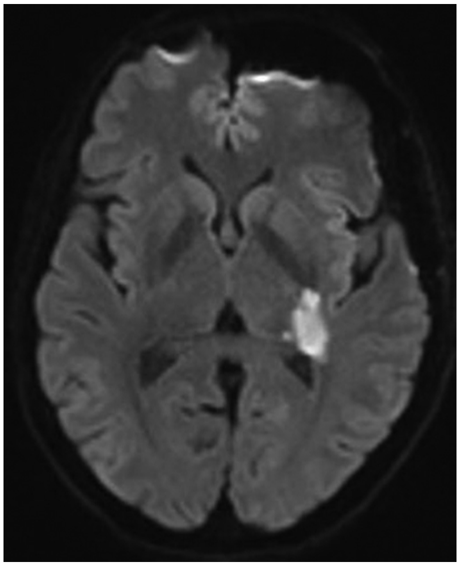

Figure 3. Diffusion-weighted magnetic resonance imaging axial view in patient 6 1 day after surgery showing an acute ischemic left thalamocapsular lesion responsible for a right-sided hemianopia and mild hemiparesis.

class I and Engel class II).[3,5-7,15,16] Discussion persists as to whether or not to resect also the entorhinal gyrus[17] and piriform cortex,[18] but this is outside the scope of this article.

Transsylvian approaches put the peri-insular vasculature at risk. Postoperative radiological vasospasm is seen in up to 26% of cases.[19] Even if the clinical importance of this vasospasm is unclear, this shows that sylvian vessel manipulation modifies blood flow in the vicinity and in a fragile patient could lead to a more important lesion. This approach thus implies more careful and timely dissection of the sylvian fissure. Subcortically, this approach, usually through the limen insulae, cuts the anterior part of the temporal stem disconnecting, at least partially, the UF.[20] For some surgeons, this is an advantage, as it causes a better disconnection between temporal and frontobasal structures, which could result in better seizure control, but this has not yet been studied in comparative studies. In the series by Yasargil et al.[16] on the transsylvian approach, of 73 patients, 35% (26 patients) had transient short-term memory impairment, 11% (8 patients) developed transient mild speech difficulties, and 1 patient developed a visual field deficit related to a postoperative subdural hematoma. In series systematically analyzing the visual field, patients presented with impairment in up to 36.6% of cases.[21] This is related to the disconnection of the most anterior part of the optic radiation, which lies on the anterior part of the roof of the temporal horn.

The subtemporal approach avoids main fiber tracts but requires increased retraction of the temporal pole, which could put unwanted traction on main veinous drainage (i.e., vein of Labbé). Two series on the subtemporal approach reported 1 patient each with a visual field defect[6,7]; the defect probably was related to an optic tract lesion instead of an optic radiation lesion. One study[22] comparing different temporal lobe surgeries for epilepsy found visual field deficit in up to 55% in the subtemporal approach, which was lower than the transsylvian approach in this study (74%). The reported numbers are higher than usually reported but underscore the fact that this approach seems to reduce visual field impairment. Interestingly, the neuropsychological results of this approach also seem better,[6,7] and the feared venous lesion related to temporal lobe retraction was not reported in published studies.

Transcortical approaches will not endanger major vascular structures during the approach, but will put white matter tracts at risk. The main transected tract depends on the approach. The trans-MTG approach will mainly transect part of the optic radiation. The anatomy of this tract has been shown to vary greatly among patients.[23-25] Tractography seems to be a useful tool to better avoid the optic radiation and has been proven to reduce postoperative visual field defect[26,27] even though it might not always be completely reliable.[28] A more inferior approach can avoid the visual pathways but endangers the inferior longitudinal fasciculus, which courses lateral and inferior to the optic tract and plays a role in visual memory. The UF is more anterior and superior to the optic radiation and is partially resected in our approach as discussed later. The middle longitudinal fasciculus (MdLF), a more recently described tract,[29] courses along the STG in its lateral aspect and might also be partially cut, as will be discussed further. The inferior fronto-occipital fasciculus courses in the posterior part of the temporal stem and should not be injured in uneventful approaches for amygdalohippocampectomies as well as the arcuate fasciculus, which usually ends in the posterior part of the STG and should not be damaged in uncomplicated approaches. Nevertheless, transection of tracts is rarely complete, and when comparing the transtemporal with trans-sylvian approach, connectivity maps seem to show comparable results, meaning that disruption of associated tracts is more or less the same.[30]

Our cortectomy on the STG is done at the junction with the temporopolar area (Brodmann area 38), even more anterior than the limen insulae. This more rostral approach allows a trajectory medial and anterior to Meyer's loop, which avoids damage to the optic radiation (**Figure 1B**) but encounters the UF partially. Traditionally, the STG is spared in temporal lobectomy on the dominant hemisphere to avoid verbal memory deficit,[31] but some authors suggest that risks mainly come from the disruption of UF more than the presence of true primary language areas in the anterior part of the STG.[32] Further, UF is suspected, in the dominant hemisphere, to play a role in retrieving proper names,[33] which may explain some of the language symptoms developed by patients after lesion to this tract. The remaining tract in the STG is the MdLF, which connects the occipitoparietal regions to the STG. The anterior termination of this tract is still debated, but recent studies[34] suggest its division into an anterior bundle MdLF connecting the temporal pole to the occipital cortex and a posterior bundle MdLF connecting the posterior STG, anterior transverse temporal gyrus, and temporal polar cortex with the superior parietal lobule and the occipital cortex. The posterior bundle

Table 2. Surgical Outcomes After Selective Amygdalohippocampectomy by Anterior Trans—Superior Temporal Gyrus Approach

Patient	Complication	Hippocampal Sclerosis	Follow-Up (years)	Engel Class	Hospital Stay (days)	Operating Time (minutes)
1	Memory disorder	+	3	III	8	250
2	0	+	4	I	7	240
3	0	+	4	I	6	230
4	Pseudomeningocele	+	3	I	8	240
5	0	+	2	I	6	230
6	Thalamic stroke*	−†	0.6	I	8	230
7	0	+	2	I	4	250
8	0	+	1.5	I	8	230
Average			2.5		7	237.5

*Cerebrovascular accident with hemiparesis 4/5 and right temporal hemianopia.
†Only angiosclerosis and gliosis.

MdLF is spared in our approach, but the anterior termination of the anterior bundle MdLF could be partially transected. Yet, the functional role of this tract is still unclear, and thus the potential functional impact of our approach in relation to this bundle cannot be evaluated.

In our cohort, only 1 patient experienced aggravated visual and working memory impairment and developed difficulties in naming individuals. Surprisingly, she was right-handed and operated on the right side. We can speculate that the UF or the anterior bundle MdLF was related to her language problem. Yet, no other patient developed such symptoms, even if operated on the left side, which implies a more complex mechanism that still needs to be understood. Regarding memory impairment, it is, again, usually encountered when operating on the dominant side[5] and is suspected to result from the resection of some residual functional hippocampus but not from white matter tract transection.

Regarding other safety considerations, one patient presented with a transient pseudomeningocele treated conservatively. The last patient presented with a postoperative thalamocapsular stroke on the same operated side. We suspected a perioperative lesion or spasm of a small thalamocapsular perforator originating from the anterior choroidal artery. As this artery lies next to the choroid plexus and is encountered in every approach, we do not attribute this complication to the anterior trans-STG course per se.

When looking at the literature, one series[3] with a trans-MTG approach reported 2.5% hemiparesis and 5% of temporary memory impairment. Visual field impairment increases up to 88%

Table 3. Literature Review of Retrospective Studies Reporting Results After Selective Amygdalohippocampectomy by Different Approaches

			Engel Class				Complications			
Reference	Approach	Patients	I	II	III	IV	Aphasia	VFD	CN III Palsy	Follow-Up (months)
Hori et al., 2007[6]	Sub-T	26	14 (54%)	8 (30%)	3 (12%)	1 (4%)	—	2 (7%)*	—	102.7 (22—176)
Tanriverdi et al., 2008[4]	Trans-MTG	50	32 (64%)	12 (24%)	6 (12%)	0	—	1 (2)	—	60
Acar et al., 2008[3]	Trans-MTG	39	37 (95%)	2 (5%)	0	0	—	—	—	25.88 ± 17.69
Little et al., 2009[7]	Sub-T	41	29 (81%)	2 (6%)	0	5 (13%)	—	1 (3)	—	22 (6—36)
Yasargil et al., 2010[16]	Trans-S	73	55 (75%)	13 (13%)	5 (6.8%)	0	8 (11%)	1 (1.3%)	3 (4.1%)	51.6 ± 38.4
Bandt et al., 2013[5]	Trans-MTG	76	50 (66%)	20 (26%)	4 (5%)	2 (3%)	2 (2.7%)	—	—	39 (12—96)
Costa et al., 2021 (present study	Trans-STG	8	7 (87.5%)	0	1 (12.5%)	0	-	1 (12.5%)†	-	39 (12—96)

VFD, visual field defect; CN, cranial nerve; Sub-T, subtemporal; Trans-MTG, trans—middle temporal gyrus; Trans-S, trans-sylvian; Trans-STG, trans—superior temporal gyrus.
*Visual field testing was performed in only 10 patients.
†Thalamic cerebrovascular accident with hemiparesis 4/5 and right temporal hemianopia.

of patients if systematically reviewed,[35] whereas our approach seems to avoid direct damage to the optic radiation. Except for our patient with a vascular complication, no patient presented with visual field impairment, confirmed by Humphrey perimetry. Of note, we used intraoperative neuronavigated tractography to increase the likelihood of avoiding the optic radiation.

This discussion would not be complete without discussing the relatively new technique of laser interstitial thermal therapy for mesiotemporal epilepsy. A multicenter study[36] with 234 patients showed a seizure freedom rate of 58% at 2 years. The authors reported 1.3% hemorrhage (not always clinically significant), 5.1% visual disturbances, and 4.3% worsening of preexisting affective disorder. Memory and language deficits could not be evaluated. This technique is thus less efficient regarding seizure control, but with lower complications and notably no white matter transection. Results from different approaches are summarized in **Table 3**.

Concerning the technical aspects, we see 2 advantages of this technique. First is the craniotomy, which can be placed higher and thus needs less muscle retraction. Even if we did not specifically address that question in our study, we believe that this leads to less postoperative discomfort. Second, in our hands, we could confirm a reduction in operative time compared with our own trans-sylvian approach with a mean operative time of 237 minutes, which represents an improvement of 80 minutes compared with our 10 last cases of trans-sylvian approach (mean operative time of 324 minutes [unpublished data]). This confirms that in the hands of the same surgeon with the same type of patient, avoiding a sylvian dissection allows significant reduction of surgical time.

This study has some limitations, such as the small number of cases, which precludes a statistically significant conclusion, and the retrospective design, which limits control of patient data. Also, a postoperative tractography study could have been used to confirm and emphasize the absence of an optic radiation lesion. Finally, a systematic postoperative neuropsychological work-up and language evaluation could have been of interest, as this points seem to differ according to approach.

CONCLUSIONS

We report a variation of the trans-STG SeAH to treat drug-resistant epilepsy in 8 patients. Functional outcome was good with 87.5% Engel class I without increase in complications compared with other techniques. Additional benefits were fewer visual field impairments, operating time savings, and reduced postoperative discomfort.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Emmanuel Costa: Formal analysis, Investigation, Resources, Writing – original draft, Visualization. **Vincent Joris:** Conceptualization, Writing – original draft. **Geraldo Vaz:** Investigation, Resources, Writing – review & editing. **Susana Ferrao Santos:** Resources. **Riëm El-Tahry:** Resources, Writing – review & editing. **Thierry Duprez:** Writing – review & editing. **Christian Raftopoulos:** Resources, Conceptualization, Surgeries, Supervision.

REFERENCES

1. Yasargil MG, Teddy PJ, Roth P. Selective amygdalo-hippocampectomy. Operative anatomy and surgical technique. *Adv Tech Stand Neurosurg*. 1985;12:93-123.
2. Niemeyer P. The transventricular amygdalo-hippocampectomy in the temporal lobe epilepsy. In: Baldwin M, Bailey P, eds. *Temporal Lobe Epilepsy*. Springfield, IL: Charles C Thomas; 1958: 461-482.
3. Acar G, Acar F, Miller J, Spencer DC, Burchiel KJ. Seizure outcome following transcortical selective amygdalohippocampectomy in mesial temporal lobe epilepsy. *Stereotact Funct Neurosurg*. 2008;86: 314-319.
4. Tanriverdi T, Olivier A, Poulin N, Andermann F, Dubeau F. Long-term seizure outcome after mesial temporal lobe epilepsy surgery: cortical amygdalohippocampectomy versus selective amygdalohippocampectomy. *J Neurosurg*. 2008; 108:517-524.
5. Bandt SK, Werner N, Dines J, et al. Trans-middle temporal gyrus selective amygdalohippocampectomy for medically intractable mesial temporal lobe epilepsy in adults: seizure response rates, complications, and neuropsychological outcomes. *Epilepsy Behav*. 2013;28:17-21.
6. Hori T, Yamane F, Ochiai T, et al. Selective subtemporal amygdalohippocampectomy for refractory temporal lobe epilepsy: operative and neuropsychological outcomes. *J Neurosurg*. 2007; 106:134-141.
7. Little AS, Smith KA, Kirlin K, et al. Modifications to the subtemporal selective amygdalohippocampectomy using a minimal-access technique: seizure and neuropsychological outcomes. *J Neurosurg*. 2009;111:1263-1274.
8. West S, Nevitt SJ, Cotton J, et al. Surgery for epilepsy. *Cochrane Database Syst Rev*. 2019;6: CD010541.
9. Harput MV, Ture U. The paramedian supracerebellar-transtentorial approach to remove a posterior fusiform gyrus arteriovenous malformation. *Neurosurg Focus*. 2017;43(video suppl 1):V7.
10. Park HH, Ronconi D, Hanakita S, et al. Endoscopic endonasal approach to the mesial temporal lobe: anatomical study and clinical considerations for a selective amygdalohippocampectomy. *Acta Neurochir (Wien)*. 2020;162:881-891.
11. Rougier A, Saint-Hilaire JM, Bouvier G, et al. Research and surgical treatment of epilepsy [in French]. *Neurochirurgie*. 1992;38(suppl 1):1-112.
12. Olivier A. Surgical techniques in temporal lobe epilepsy. *Clin Neurosurg*. 1997;44:211-241.
13. Olivier A. Transcortical selective amygdalohippocampectomy in temporal lobe epilepsy. *Can J Neurol Sci*. 2000;27(suppl 1):S68-S76 [discussion: S92-S96].
14. Mathon B, Clemenceau S. Selective amygdalohippocampectomy via trans-superior temporal gyrus keyhole approach. *Acta Neurochir (Wien)*. 2016;158:785-789.
15. Salanova V, Markand O, Worth R. Temporal lobe epilepsy surgery: outcome, complications, and late mortality rate in 215 patients. *Epilepsia*. 2002; 43:170-174.
16. Yasargil MG, Krayenbuhl N, Roth P, Hsu SP, Yasargil DC. The selective amygdalohippocampectomy for intractable temporal limbic seizures. *J Neurosurg*. 2010;112:168-185.
17. Bonilha L, Yasuda CL, Rorden C, et al. Does resection of the medial temporal lobe improve the outcome of temporal lobe epilepsy surgery? *Epilepsia*. 2007;48:571-578.
18. Galovic M, Baudracco I, Wright-Goff E, et al. Association of piriform cortex resection with surgical outcomes in patients with temporal lobe epilepsy. *JAMA Neurol*. 2019;76:690-700.
19. Schaller C, Jung A, Clusmann H, Schramm J, Meyer B. Rate of vasospasm following the transsylvian versus transcortical approach for selective amygdalohippocampectomy. *Neurol Res*. 2004;26: 666-670.
20. Straus D, Byrne RW, Sani S, Serici A, Moftakhar R. Microsurgical anatomy of the transsylvian translimen insula approach to the mediobasal temporal lobe: technical considerations and case illustration. *Surg Neurol Int*. 2013;4: 159.
21. Yeni SN, Tanriover N, Uyanik O, et al. Visual field defects in selective amygdalohippocampectomy for hippocampal sclerosis: the fate of Meyer's loop during the transsylvian approach to the temporal

horn. *Neurosurgery*. 2008;63:507-513 [discussion: 513-515].

22. Schmeiser B, Daniel M, Kogias E, et al. Visual field defects following different resective procedures for mesiotemporal lobe epilepsy. *Epilepsy Behav*. 2017;76:39-45.

23. Nilsson D, Starck G, Ljungberg M, et al. Intersubject variability in the anterior extent of the optic radiation assessed by tractography. *Epilepsy Res*. 2007;77:11-16.

24. Falconer MA, Meyer A, Hill D, Mitchell W, Pond DA. Treatment of temporal-lobe epilepsy by temporal lobectomy; a survey of findings and results. *Lancet*. 1955;268:827-835.

25. Winston GP. Epilepsy surgery, vision, and driving: what has surgery taught us and could modern imaging reduce the risk of visual deficits? *Epilepsia*. 2013;54:1877-1888.

26. Winston GP, Daga P, White MJ, et al. Preventing visual field deficits from neurosurgery. *Neurology*. 2014;83:604-611.

27. Piper RJ, Yoong MM, Kandasamy J, Chin RF. Application of diffusion tensor imaging and tractography of the optic radiation in anterior temporal lobe resection for epilepsy: a systematic review. *Clin Neurol Neurosurg*. 2014;124:59-65.

28. Lilja Y, Nilsson DT. Strengths and limitations of tractography methods to identify the optic radiation for epilepsy surgery. *Quant Imaging Med Surg*. 2015;5:288-299.

29. Menjot de Champfleur N, Lima Maldonado I, Moritz-Gasser S, et al. Middle longitudinal fasciculus delineation within language pathways: a diffusion tensor imaging study in human. *Eur J Radiol*. 2013;82:151-157.

30. Busby N, Halai AD, Parker GJM, Coope DJ, Lambon Ralph MA. Mapping whole brain connectivity changes: the potential impact of different surgical resection approaches for temporal lobe epilepsy. *Cortex*. 2019;113:1-14.

31. Alpherts WC, Vermeulen J, van Rijen PC, da Silva FH, van Veelen CW. Dutch Collaborative Epilepsy Surgery Program. Verbal memory decline after temporal epilepsy surgery? A 6-year multiple assessments follow-up study. *Neurology*. 2006;67:626-631.

32. Han Z, Ma Y, Gong G, He Y, Caramazza A, Bi Y. White matter structural connectivity underlying semantic processing: evidence from brain damaged patients. *Brain*. 2013;136(pt 10):2952-2965.

33. Von Der Heide RJ, Skipper LM, Klobusicky E, Olson IR. Dissecting the uncinate fasciculus: disorders, controversies and a hypothesis. *Brain*. 2013;136(Pt 6):1692-1707.

34. Latini F, Trevisi G, Fahlstrom M, et al. New insights into the anatomy, connectivity and clinical implications of the middle longitudinal fasciculus. *Front Neuroanat*. 2020;14:610324.

35. Mengesha T, Abu-Ata M, Haas KF, et al. Visual field defects after selective amygdalohippocampectomy and standard temporal lobectomy. *J Neuroophthalmol*. 2009;29:208-213.

36. Wu C, Jermakowicz WJ, Chakravorti S, et al. Effects of surgical targeting in laser interstitial thermal therapy for mesial temporal lobe epilepsy: a multicenter study of 234 patients. *Epilepsia*. 2019;60:1171-1183.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 6 November 2021; accepted 10 December 2021

Citation: World Neurosurg. (2021).
https://doi.org/10.1016/j.wneu.2021.12.034

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

Available online: ***www.sciencedirect.com***