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The impact of visual field defects following anterior temporal lobectomy

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Abstract

Objective: This prospective study aimed to quantify visual field defects (VFDs) along with other defects in ophthalmic functions after anterior temporal lobectomy (ATL) in patients with mesial temporal lobe epilepsy (MTLE) and their impact on quality of life using a VFQ-25 questionnaire. *Methods:* Ophthalmic evaluation was done during pre-operative evaluation as well as 3 months after surgery. It included the Best Corrected Visual Acuity (BCVA), visual field evaluation, colour vision examination, fundoscopy, extraocular movements and diplopia charting. Visual field evaluation was done using a Humphrey field analyser. The foveal threshold (FT), mean deviation (MD) and pattern standard deviation (PSD) were calculated for each patient. Quality of life assessment was done using the Visual Functioning Questionnaire-25 (VFQ-25). Two-tailed independent T-tests and Chi-square tests were performed for comparison of results. *Results:* Thirty-four patients were included in this study (23 men and 11 women). The mean age was 26.6 years (range 9-44 years). Post-operatively, none complained of a visual field disturbance. Thirty-one (91.17%) of 34 patients had a new quantifiable superior quadrantanopia. FT, MD and PSD of patients ranged between 29db to 40db, -1.23 to -14.28 and 1.75 to 15.34, respectively. There was no detectable abnormality in visual acuity, colour vision, fundoscopy, diplopia charting or extraocular movements. VFQ-25 scores ranged from 84 to 100. The difference between VFQ scores of patients with and without quadrantanopia was not significant. *Conclusion:* Standard ATL produces asymptomatic VFDs that do not affect quality of life. A combined effort of the neurologist and ophthalmologist is recommended to counsel the patient before surgery.

Keywords: Temporal lobe epilepsy, visual field defects, anterior temporal lobectomy, quality of life

INTRODUCTION

Anterior temporal lobectomy with amygdalohippocampectomy (ATL) is the traditional approach in the surgical treatment of drug-resistant temporal lobe epilepsy (TLE). Visual field defects (VFDs) are a common occurrence after ATL, with an incidence of about 52% to 97% in various studies.[1-5] VFDs typically occur in the superior homonymous field contralateral to the resection and are due to disruption of Meyer's loop. The extent of VFD reflects the retinotopic organisation of fibres, with crossed and uncrossed fibres coursing in three major bundles. Fibres of the anterior bundle closely associated with the temporal horn of the lateral ventricle are at greatest risk during resection. Variability in previous studies can be attributed to factors such as heterogeneity in VFD estimation, differences in the nature and extent of surgery and anatomic variability of Meyer's loop.[6]

VFDs in the post-operative period can jeopardize the functional skills of patient like driving ability and thus their social independence. Another concern is in the context of pre-surgical counselling of patients undergoing ATL where VFDs after surgery need to be detailed. Hence, a combined effort of Neurologist and Ophthalmologist becomes important to quantify it and counsel the patient before surgery.

However, recent advances like pre-operative

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tractography as was demonstrated from our group, intra-operative MRI and neuronavigation have reduced the incidence of VFDs substantially.[7,8] Still, the impact of such deficits and their effect on post-operative quality of life has been a great concern among caregivers.

The current study aimed to estimate the VFDs occurring after standard ATL for intractable TLE (with mesial temporal sclerosis as pathological substrate). The objectives while doing so were: 1. To quantify VFDs occurring after ATL for drug-resistant TLE; 2. To estimate any other defects in ophthalmic functions after ATL (visual acuity, contrast sensitivity, colour vision, ocular movements); 3. To compare the side of resection and the extent of VFDs; 4. To estimate the quality of life using a VFQ-25 questionnaire.

METHODS

The study was a post hoc analysis of a prospectively acquired database conducted at the R. Madhavan Nayar Center for Comprehensive Epilepsy Care, Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum, Kerala, South India (a tertiary referral centre for advanced epilepsy care and has completed more than 2500 epilepsy surgeries so far since 1995) and Regional Institute of Ophthalmology, Trivandrum (a tertiary academic and referral centre for ophthalmic diseases). The study was conducted after obtaining the institutional ethics committee clearance.

Thirty-six consecutive patients awaited surgery during the study period. Two children were excluded from the study (Figure 1). Pre- and post-operative data were obtained from 34 patients who underwent standard ATL for drug-resistant mesial TLE (MTLE) in SCTIMST. The side of resection was determined after obtaining electro-clinical-radiological concordance from a team comprising Epileptologists, Neurosurgeons, Imageologists, Psychologist(s), Speech pathologist(s) and Occupational rehabilitation expert(s).

Neurosurgeon(s) experienced in epilepsy surgery resected a maximum of 6.0 to 6.5 cm of the anterior lateral non-dominant temporal lobe or 4.0 to 4.5 cm of the dominant temporal lobe. The mesial resection included the amygdala and, at a minimum, the anterior 1.0 to 3.0 cm of the hippocampus (most commonly, 4.0 cm). Optic radiation is usually transected irrespective of the extent and method of cortical removal due to the anterolateral corridor into the inferior horn.

Best Corrected Visual Acuity (BCVA), colour vision examination, fundus examination, extraocular movements, diplopia charting and visual field evaluation were obtained. The various outcome variables measured were degree of field defect, mean deviation (MD), pattern standard deviation (PSD), foveal threshold (FT), and changes in any other visual functions like BCVA, colour vision, fundus changes, extraocular movements, and Visual Functioning Questionnaire 25 (VFQ-25) score. Patients unable to do field testing due to other neurologic problems, children, patients with preexisting VFDs or other causes for VFD like glaucoma and patients who gave

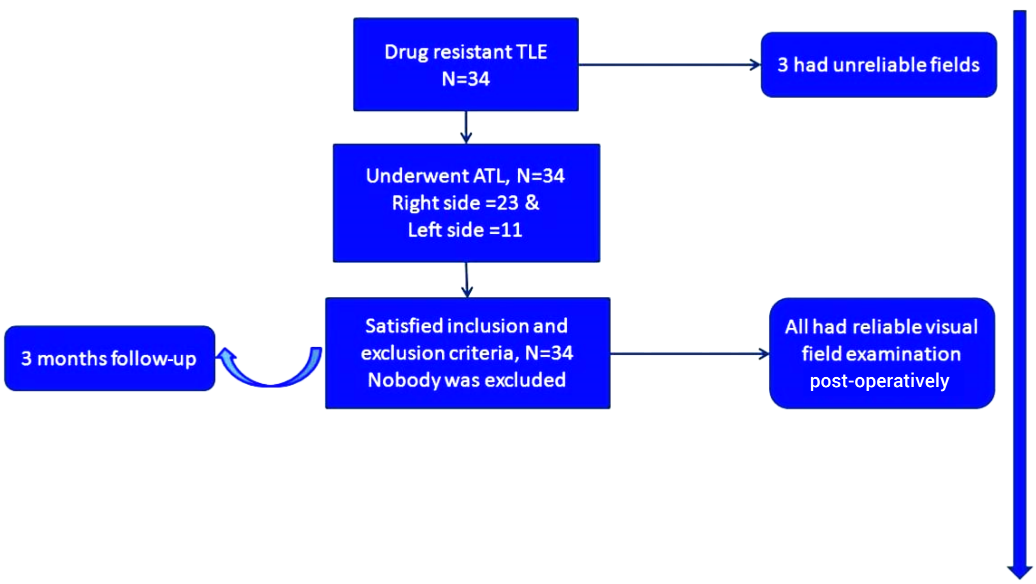

Figure 1. Flow chart showing the study protocol and the cohort selected.

unreliable fields on repeated testing at least 3 times consecutively were excluded from the study. The reliability criteria used were fixation losses of less than 20% and false positive and false negative errors of less than 33%.[9] Best Corrected Visual Acuity (BCVA) was assessed using a Snellen chart examined at 6 meters. BCVA of < 6/6 was considered abnormal. A colour vision examination was done with an Ishihara chart. Fundus was examined by slit lamp biomicroscopy using a 90D lens. Extraocular movements were checked in all 9 cardinal positions. Diplopia charting was done after dissociating both eyes with red and green goggles.

Visual field evaluation

Visual field testing was obtained with automated perimetry, which is the gold standard. Testing was done with the 30-2 program on the Humphrey field analyser (Humphrey Instruments model 630/640), with a white-on-white Goldman Size III target with threshold strategy, which tested 76 points in the central 60 degrees of vision. The threshold for light detection was determined for each point using the staircase method. The reliability criteria used were fixation losses of less than 20% and false positive and false negative errors of less than 33%.[9]

Quadrantanopia was diagnosed if any of the following was present: a) depression of thresholds by 5 dB or more in 3 or more contiguous points adjacent to the vertical meridian in the involved quadrant as compared to their mirror image points across the vertical meridian; b) pattern deviation plot showed 3 or more points adjacent to the vertical meridian in the involved quadrant depressed to the 1 % probability level with normal mirror image points across the vertical meridian. Fixation losses, false positive errors, and false negative errors were recorded. As part of the Humphrey program, foveal threshold, mean deviation (MD) and pattern standard deviation (PSD) were calculated for each patient. The MD represents the overall extent of depression of the field and is measured in decibels; zero is normal for age. The PSD quantifies the SD of the points in the pattern deviation determination (plot) relative to the neighbouring points and is an indication of how much each point differs from its neighbours. A higher PSD indicates higher variability among neighbouring points. MD and PSD values with $p \leq 0.05$ were considered significant in the study for analysis. Data was obtained pre-operatively and 3 months post-operatively. Adjoining oedema and blood or CSF collection in the operated site may cause errors in the immediate post-operative period and hence warrant a 3-month post-surgical evaluation.

Visual Functioning Questionnaire (VFQ-25)

Quality of life assessment was done using the Malayalam (local language) and English versions of Visual Functioning Questionnaire 25 (VFQ-25), version 2000 of National Eye Institute (*PB/SA National Eye Institute Visual Functioning Questionnaire-25 (VFQ-25) version 2000 (self-administered format)*.[10] Part-1 consists of questions related to general health and vision, Part-2 consists of questions related to difficulty with activities, and Part-3 consists of questions related to responses to vision problems. The various subscales under which questions are grouped are General Vision, Near Activities, Distance Activities, Vision Specific activities (Social Functioning, Mental Health, Role Difficulties, Dependency), Driving, Colour Vision and Peripheral Vision. Scoring was done based on the NEI VFQ-25 Scoring Algorithm, August 2000. Thus, a subscale score and a composite score were obtained. Comparisons were made between groups based on these scores.

Inclusion and Exclusion Criteria

Inclusion criteria: Consecutive patients with drug-resistant MTLE-HS awaiting surgery.

Exclusion criteria: 1. Patients who are unable to do fields due to neurologic problems; 2. Children who could not cooperate with testing; 3. Patients with preexisting visual field defects due to other neurologic (multiple sclerosis, intracranial space-occupying lesions like pituitary tumours, CNS vasculitis, etc.) or ocular causes; 4. Patients who gave unreliable fields on repeated testing, at least 3 times consecutively.

Statistical analysis

The Statistical Package SPSS Version 17 (SPSS, Chicago, Illinois, USA) was used for statistical analysis. A two-tailed independent t-test and Chi-square test were performed for the comparison of results and a p-value less than 0.05 was considered as statistically significant.

RESULTS

Of the 34 patients (after excluding 2 children preoperatively), 23 (67.64%) were males and 11

(32.36%) were females. Their age ranged from 9 to 44 years (median age-26.5 years). Automated perimetry pre-operatively was unreliable in 3 patients. Out of 34 patients screened, these unreliable fields during pre-operative examination in 3 patients were attributed to their inability to cooperate with examination as part of their disease. They were not excluded as their post-operative fields were reliable on all occasions. None of the patients had a significant field defect in the quadrant and were at risk pre-operatively. Of the 34 patients, 23 (67.64%) underwent a right ATL and 11 (32.36%) left ATL (Table 1).

Post-operatively, none of the patients complained of any visual field disturbance. The follow-up was done 3 months after the surgery. Seven (20.5%) patients had vague visual complaints regarding vision and visual concentration. Thirty-one (91.17%) had new quantifiable VFD. Qualitatively, the visual field defects were superior quadrantanopia, which met our definition (Figure 2). Out of 34 patients, 3 (8.82%) did not have any quadrantanopia bilaterally, 2 had ipsilateral quadrantanopia only sparing their contralateral eye, and one patient had quadrantanopia in the contralateral eye only. On inspection, only 3 (9.67%) had defects which appeared congruous. Twenty-eight (90.32%) patients had incongruous quadrantanopia.

The mean population measures of quantitative visual field analysis are depicted in Figure 3A. Foveal thresholds (FT) of patients in the study group were in the range between 29db to 40db. Mean FT was 33.59 ± 2.95db for ipsilateral fields and 33.68 ± 2.52db for contralateral fields, and the difference was not statistically significant (p-value 0.865). The mean Deviation (MD) ranged from -1.23 to -14.28. The mean MD was -8.02 ± 3.25 for ipsilateral fields and -6.82 ± 3.13 for contralateral fields. Pattern standard deviation (PSD) ranged from 1.75 to 15.34. Mean PSD was 9.97 ± 4.24 for ipsilateral fields and 8.75 ± 3.83 for contralateral fields. There was a significant difference in the mean values of MD and PSD between ipsilateral and contralateral eyes (p-values 0.002 and 0.001). Of the 34 patients examined, 29 (85.29%) had an ipsilateral VFD greater than contralateral visual field defect.

On comparing the quadrantanopias in 31 patients, it appeared to be significant, with MD in 27 (87.1%) patients in their ipsilateral eye and 23 (74.19 %) patients in their contralateral eye and PSD in 30 (96.7%) patients in their ipsilateral eye and 29 (93.54%) patients in their contralateral eye, but these differences between the two sides were not statistically significant (p-value 0.2) (Figure 3B). Difference between quadrantanopias which occurred after the right (PSD 10.23 ± 4.17) and left-sided (PSD 10.69 ± 3.94) resections were also not statistically significant (p-value 0.7) (Figure 3C). Other visual functions like BCVA, colour vision, fundus examination, diplopia charting and extraocular movements detected no anomalies. VFQ-25 scores ranged from 84 to 100. The difference in VFQ scores of patients with (median VFQ score 100 (quartiles 91,100)) and without quadrantanopia (median VFQ score 90 (quartiles 84,98)) was not statistically significant (p-value 0.12) (Figure 3D).

Of the 34 patients, 11 patients drove vehicles, and among these, 9 patients had VFDs, and they did not experience any difficulty during driving. Significant VFDs were not associated with any difficulties in driving, as indicated by a subscale and composite score of VFQ.

DISCUSSION

The incidence of new quantifiable VFD was 91.17% in our study. The previous studies showed a VFD in 52% to 97% of patients after ATL.[1-5,11-13] The higher incidence here than in most of the previous studies could be due to the higher sensitivity and quantifiability of automated perimetry, which is the current gold standard. Studies that used Bjerrum campimetry showed a lower incidence, 52%, whereas those using automated perimetry on 32 patients who underwent ATL reported an incidence of 97%, which is comparable to ours.[2,11,14]

Despite a 91% incidence of VFD, none of our patients complained of visual field disturbances.

Table 1: Demographic characteristics of the study population (N=34)

Sex		Age distribution in years n (%)				Side of resection n (%)	
Males n (%)	Females n (%)	<30	10-20	21-30	>30	Right	Left
23(67.64)	11(32.36)	1(2.94)	9(26.48)	12(35.29)	12(35.29)	23(67.64)	11(32.36)

N – number; % - percentage.

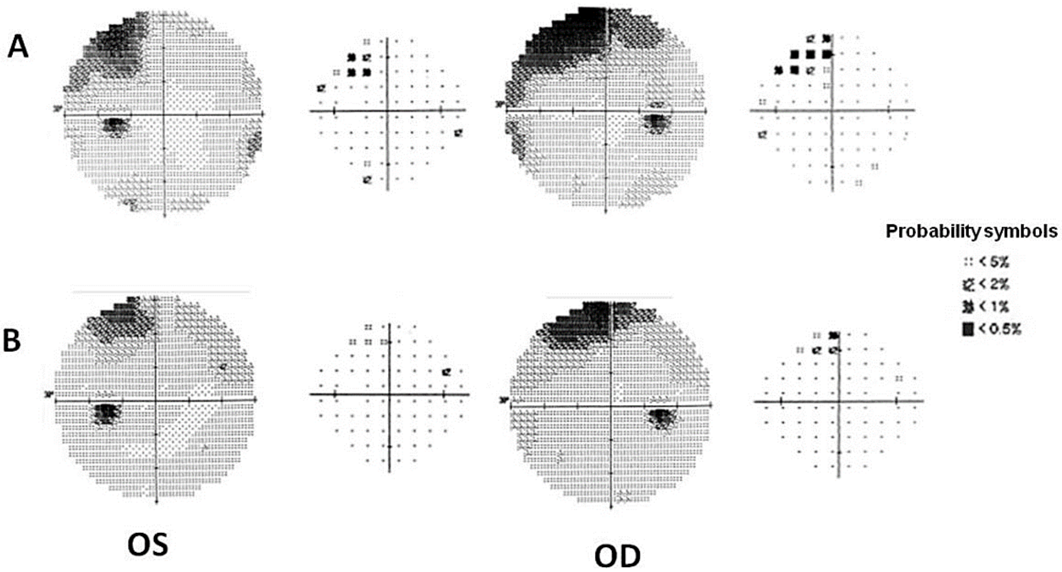

Figure 2. Grayscale and pattern deviation plots from the Humphrey visual field analyser in two patients after right ATL; the contralateral eye has smaller defects, and points near the vertical midline are spared. (A) An example of a typical visual field defect with superior quadrantanopia, called "pie in the sky" appearance. (B) An example of a minimal VFD.
OS left eye; OD right eye.

This was in concordance with the study by Egan *et al*. and Katz *et al*. while in discordance with the one by Tecoma *et al*., where 8% of patients noticed symptomatic deficits.[15,16]

As expected, the superior quadrant was preferentially affected (Figure 4A). There were variations in the extent of field involvement between patients. MD ranged from -1.23 to -14.28.

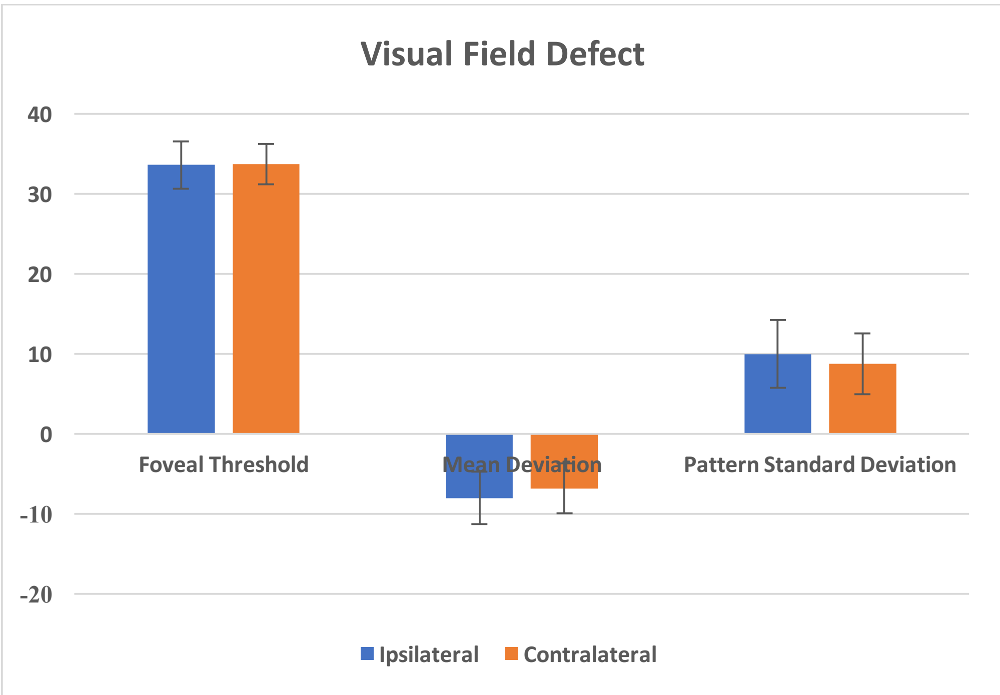

Figure 3A. Quantitative visual field defects: The bar chart depicts the mean and standard deviation (SD) of various measures of quantitative visual field analysis.

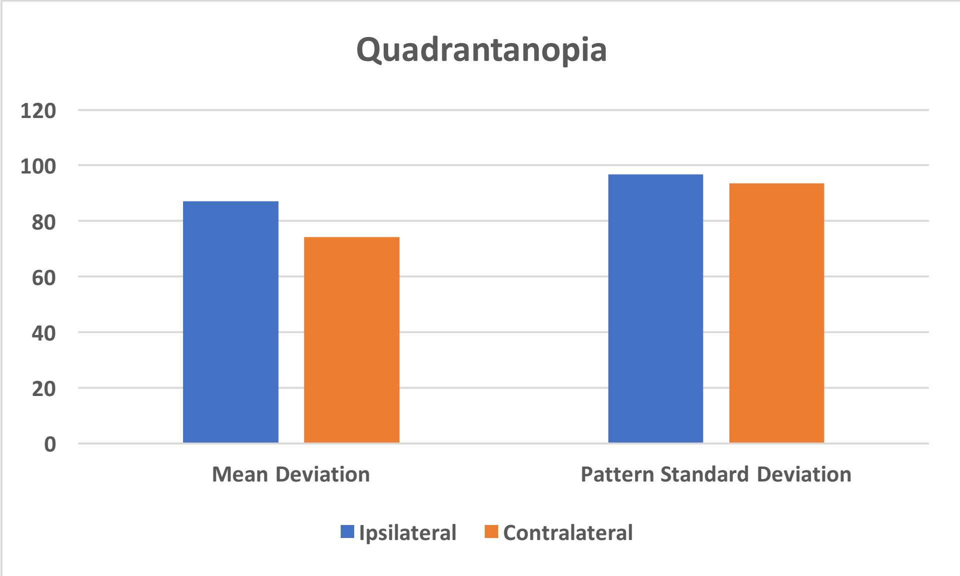

Figure 3B. Quadrantanopia assessment: The bar chart depicts the percentage of various measures between the ipsilateral and contralateral eye in patients with quadrantanopia.

PSD ranged from 1.75 to 15.34. The range of severity in the field defects with excisions of any given magnitude is probably largely accounted for by the variations in the extent of the anterior sweep of the radiation from one person to another, as well as by variations in the size of the temporal lobe with reference to the rest of the brain.[17]

The field defects in the ipsilateral eye were found to be more than the contralateral eye on comparing the mean values of MD and PSD. This difference was found to be statistically significant. A previous study by Hughes *et al*. also established that the superior quadrant was affected to a greater degree in the ipsilateral eye than in the contralateral one.[14] This supports the anatomic model suggested by others, in which the fibres of Meyer's loop from the ipsilateral eye course anteriorly and laterally to those from the contralateral eye (Figure 4B.) and, therefore, are at greater risk during ATL.[18]

Among the 31 patients with superior quadrantanopia, a greater number of patients (96.77%) had significant PSD in their ipsilateral eye as compared to their contralateral eye

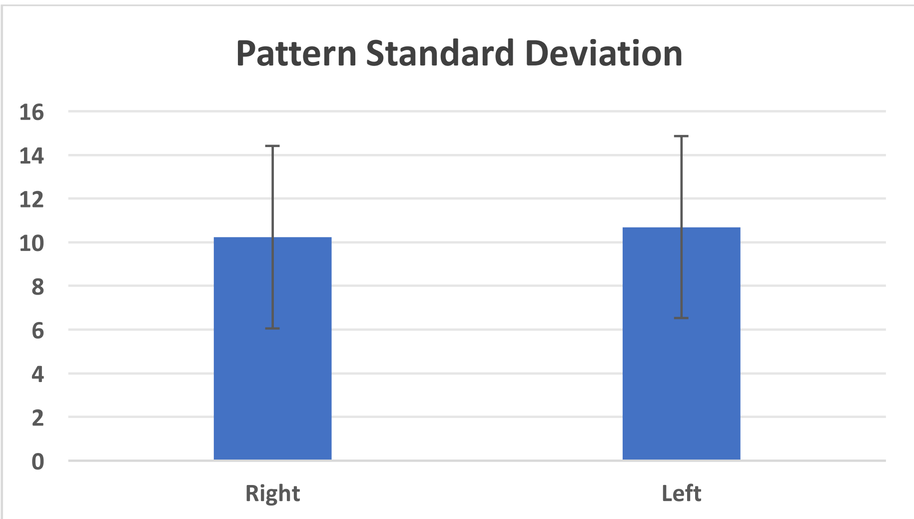

Figure 3C. Bar chart depicts (mean and SD) pattern standard deviation of patients with quadrantanopia comparing between right and left side.

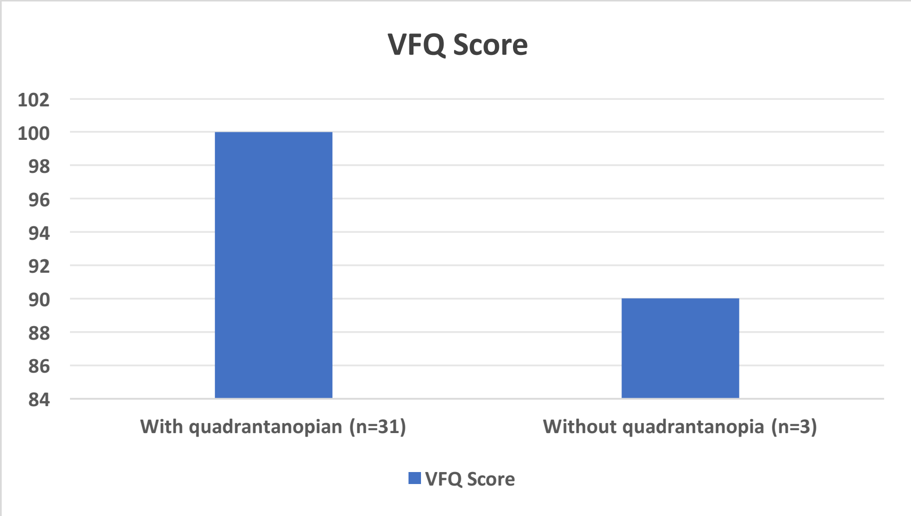

Figure 3D. VFQ score comparison: The bar chart depicts the comparison of the median VFQ score between patients with and without quadrantanopia.

(93.54%), although not statistically significant. This shows that though ipsilateral field defects appear to be larger than the contralateral ones, both are significant enough, with MD and PSD showing significant affection. Therefore, significant quadrantanopia can occur in both eyes to almost equal degrees following ATL. Also, when comparing the quadrantanopia that occurred in right-sided versus left-sided resections, the mean PSD values were 10.69 and 10.23, respectively, with no statistical significance. Therefore, though resections were typically larger in the right hemisphere, there was no effect of the side of resection on VFD, as noted by several others.[13] However, a higher frequency of extensive deficits after left-sided resections in the later studies can be explained by anatomic variability of Meyer's loop and variability in the size of the temporal lobe.[19] Anterior extension of left Meyer's loop than the right side was supported by studies, including ours, employing diffusion tensor imaging tractography (DTIT) and might be probably due to language lateralisation of the left side and needs further studies for elucidating the reason.[7,20-22]

We found that the central 3 degrees were

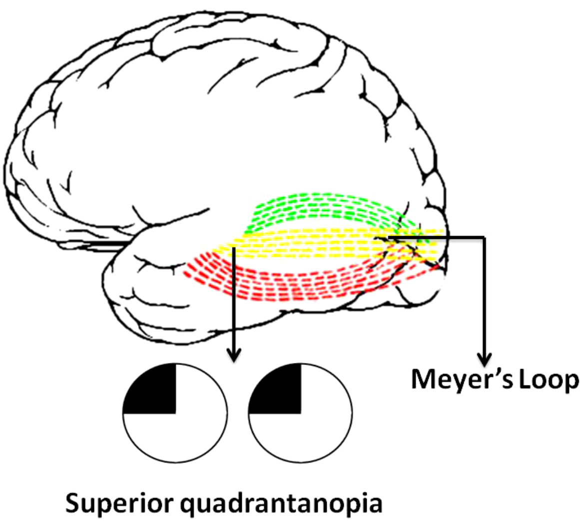

Figure 4A. Visual pathways: A temporal lobe lesion results in damage to Meyer's loop and causes a VFD with contralateral superior quadrantanopia (also called "pie in the sky").

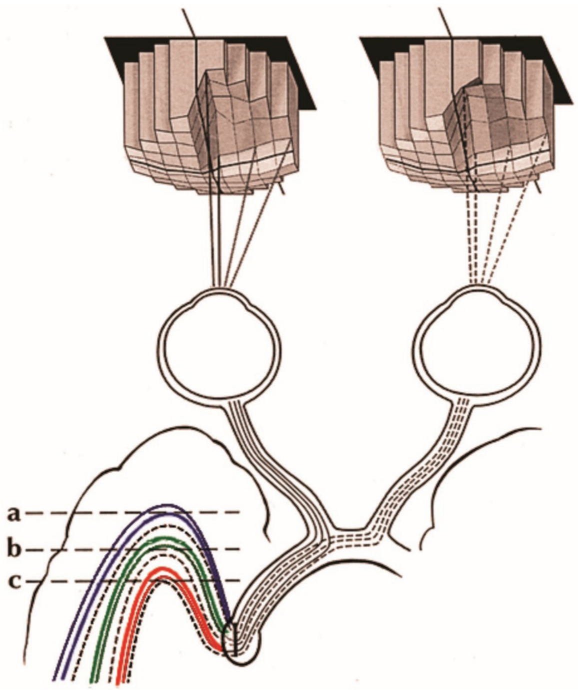

Figure 4B. Organisation of Meyer's loop, each visual field is represented graphically in three dimensions, with the affected superior quadrant facing upward and to the right. The bold lines over each field represent the horizontal and vertical meridians. The fibres from the medial sector (blue lines) are the anterior-most, and the fibres carrying central vision are posteriorly located (red lines). The fibres from the lateral sector are intermediate in location (green lines). The fibres from the contralateral eye (dashed lines) are relatively posterior to those from the ipsilateral eye (solid lines), with maximum separation in anterior fibres followed by lateral sector and central vision. A resection at ***level a*** predominantly affects the medial sector of the ipsilateral eye. A resection at ***level b*** will affect both medial sectors and the lateral sector of the ipsilateral eye to a greater degree than the contralateral eye. Central vision is still relatively spared. A resection at ***level c*** will affect both eyes almost equally in the medial and lateral sectors, as well as the most medial inferior test point.

spared in a large number of patients, ipsilaterally in 23 (67.64%) and contralaterally in 19 (55.88%) patients. This is because the fibres carrying information from this area are represented more posteriorly in Meyer's loop (Figure 4B) and were much less likely to be damaged surgically. Alternatively, fibres subserving central vision may have a greater level of redundancy and may be less prone to damage.

The VFQ-25 quality of life assessment for these patients revealed a comparable difference in composite scores between patients who developed quadrantanopia and those who did not. This finding, which has not been previously reported, suggests that the field defect may not significantly affect these patients' quality of life or cause disability. However, since we did not investigate each VFQ sub-scale score separately, we are unable to ascertain how VFD affected each subdomain, which indicates that future research is warranted in this field. Of the 34 patients, 11 drove vehicles, and among these, 9 had VFDs, but they did not experience any difficulty during driving. However, whether these VFDs would disqualify them from driving licenses was not addressed in the present study since each country has their varied guidelines.

Minimally invasive surgical techniques like gamma knife radiosurgery and stereotactic laser thermo-ablation are now increasingly being studied for their effect on seizure outcome although the ROSE trial showed ATL is better for seizure outcome, although less invasive ones can probably prevent quadrantanopia from occurring.[23] In a study by Quigg *et al*., the incidence of VFDs after gamma knife radiosurgery was 91% and VFDs did not have any impact on driving status at a 3-year follow-up.[24] However, the assessment of driving status was only done through a self-report by patients for which no validated tools like VFQ

25 were used. Grewal *et al*., also reported VFDs were not uncommon after laser ablation for mesial temporal epilepsy.[25] So resorting to standard ATL would be better to attain greater seizure freedom since it is clear that the visual deficit is not going to affect their day-to-day living.

One important strength of our study is the post-operative VFD assessment, which was done using the current gold standard, i.e., automated perimetry. A uniform surgical technique (none underwent selective AH) was used for all subjects. Pre- and post-operative automated perimetry was done homogeneously in patients to assess VFD accurately unlike in most other studies. The most unique strength of our study is the assessment of quality of life with the use of a vision-specific quality of life assessment.

We accept the following shortcomings also. As the study population underwent standard ATL, the incidence of VFD after the inferior temporal gyrus approach and selective AH could not be ascertained.[15,26] We analysed only the VFQ composite score and did not investigate the VFQ sub-scale which takes into account the twelve domains of the VFQ-25 separately.[10] Although VFD did not affect quality of life, whether they would disqualify patients from obtaining driver's licenses was also not addressed.[27]

In conclusion, ours is the first study to the best of our knowledge addressing the effect of VFDs after ATL on the quality of life. Standard ATL done for drug-resistant temporal lobe epilepsy produces asymptomatic field defects only. VFDs are quantifiable but are variable due to the anatomic variability between individuals. VFDs do not affect the quality of life of these patients as assessed by the VFQ-25 questionnaire. This information is important in the pre-surgical counselling of patients.

DISCLOSURES

Ethics: Approval of this study was granted by the Ethics Committee of Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala, India. Informed consent was obtained from all individual participants included in the study.

Data availability: All data generated during this study are included in this article. Further enquiries can be directed to the corresponding author.

Financial support: None

Conflict of interests: None

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