Indications and surgical management for movement disorders.

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KEYWORDS	ABSTRACT:
Indications, surgical management, movement disorders	**Background:** Movement disorders encompass a heterogeneous group of neurological conditions affecting motor control. These disorders are broadly classified into hypokinetic (e.g., Parkinson's disease [PD]) and hyperkinetic (e.g., dystonia, essential tremor). While pharmacological treatment remains the mainstay, stereotactic neurosurgical procedures, including lesioning techniques such as thalamotomy and pallidotomy, offer an effective alternative for medically refractory cases. Despite the high success rate of deep brain stimulation (DBS), financial constraints in developing countries necessitate more cost-effective approaches like lesioning procedures. **Aim**: This study aimed to evaluate the outcomes of lesioning procedures in patients with movement disorders, specifically Parkinson's disease, dystonia, and essential tremor. The study also sought to establish a standardized protocol for surgical management, considering economic constraints, and to enhance collaboration between neurology and neurosurgery departments for optimal patient care. **Patients and Methods:** A prospective clinical study was conducted at Cairo University Hospitals from May 2022 to February 2023, enrolling 21 patients diagnosed with movement disorders. Patients underwent stereotactic lesioning procedures, including thalamotomy and pallidotomy, based on clinical symptomatology. Preoperative and postoperative assessments utilized standardized scoring systems such as the Unified Parkinson's Disease Rating Scale (UPDRS), TETRAS (essential tremor rating scale), and the Unified Dystonia Rating Scale (UDRS). Statistical analysis was performed using SPSS version 26, with significance set at $P < 0.05$. **Results:** Among the 21 patients, 16 had Parkinson's disease, 3 had essential tremors, and 2 had dystonia. Postoperative assessments showed significant improvement across all groups. In Parkinson's disease patients, UPDRS III scores improved by 46.3% in the off-medication state and 57.7% in the on-medication state ($P < 0.001$). Tremors decreased by 60% in the off state and 75% in the on state. Essential tremor patients exhibited a 41.5% improvement in TETRAS scores ($P = 0.011$), while dystonia patients showed a 41.5% improvement in UDRS scores ($P = 0.033$). Mild dysarthria was reported in 18.75% of Parkinson's patients, with one case of postoperative subdural hematoma. **Conclusion:** We conclude that lesioning procedure should be revisited globally using the modern techniques of targeting and controlled thermal lesion protocols guided by capsular somatotopy and intraoperative EMG monitoring, that will improve the outcome dramatically

1. Introduction

Movement disorders are a group of diseases characterized by being clinically, pathologically, and genetically heterogeneous. They affect the planning, control, and execution of movement. They can be subgrouped into hypokinetic and hyperkinetic disorders [1].

The hypokinetic disorders consist of akinesia, bradykinesia, and rigidity. Akinesia is defined as a paucity of movement, while bradykinesia refers to slowness of movement. Rigidity is an involuntary increase in muscle tone felt equally in flexors and extensors. Cogwheel rigidity describes superimposed tremors. Hypokinetic disorders include PD and other forms of parkinsonism [1].

Hyperkinetic disorders are characterized by an excess amount of movement, either spontaneous or in response to a voluntary movement or another stimulus. They are often involuntary, though some may have a voluntary component. The most common types of these disorders include tremor, dystonia, tics, chorea, ballismus, and myoclonus [1].

Although medications are the mainstay of therapy for movement disorders, neurosurgery has played an important role in their management for the past 65 years. Surgery is now a viable and safe option for patients with medically intractable Parkinson's disease, essential tremor, and dystonia [2].

However, stereotactic surgery regained attention back in the 1990s. Functional surgery is again accepted as one of the treatment modalities for movement disorders [3].

Approaching the end of the 1980s, Benabid et al. made the important discovery that chronic electrical high-frequency stimulation (deep brain stimulation [DBS]) of various basal ganglia targets is as effective as lesioning for the treatment of different movement disorders.

The economic downturns that hit the world in the past few years had their highest impact on developing countries. The tough economic situation and reduction in services like health insurance may not allow a fair and equal opportunity for treatment to all citizens. Developing nations now struggle with large-scale conflicts, income inequality, poverty, food and water security, and lack of economic opportunity and employment, all of which play an important role in the development of the health sector in those nations.

Through the last century, the field of functional and stereotactic neurosurgery has undergone great evolution in all aspects, rendering this field a real state of the art. Medicine in general, and neurosurgery in particular, initially targeted saving patients' lives as the main priority of management. Later, with the improvement of both understanding of neurophysiology and operative techniques, the concept of improving the quality of life emerged. Many procedures now aim to improve patients' quality of life by alleviating pain or enhancing functional capacity. However, these procedures are commonly very expensive and highly sophisticated [4].

It would be unfair to quit treating these patients with "non-essential" neuro-pathologies—if compared to trauma or cerebrovascular diseases—due to the high cost of the DBS device and later battery replacement. Improving these patients' quality of life can be achieved via lesioning procedures, which are not necessarily equivalent to DBS, but results can be comparable to it [4].

Disadvantages of DBS include the bulkiness of stimulators, which can be uncomfortable for the patient. Stimulators require regular adjustment, especially in the early months after insertion. Stimulator units need to be replaced every 3–5 years (for non-rechargeable types). Lesions do not have these problems, but unlike stimulators, side effects may not be reversible. Other disadvantages of lesioning include the inability to switch off complications of a lesion, potential waning of beneficial effects, and the inability to adjust lesions [4].

DBS and radiofrequency lesioning are commonly used in the treatment of movement disorders. The main surgical targets are the subthalamic nucleus (STN), globus pallidus internus (GPi), and ventral intermediate nucleus (VIM) of the thalamus [5].

Many articles discuss the efficacy of stereotactic surgical techniques for movement disorders. Some show the superiority of DBS over lesioning of functional targets, while others demonstrate the cost-effectiveness of lesioning with results comparable to DBS [5].

This study aimed to improve the management and clinical outcomes of surgical management in movement disorders.The primary objectives of this study were to assess the outcomes of lesioning procedures in patients with various movement disorders at three and six months post-procedure, ensuring they met the selection criteria outlined in this protocol. Additionally, the study aimed to propose a standardized protocol for the surgical management of movement disorders, tailored to the available resources and facilities at our institute. Another key objective was to establish a multidisciplinary approach involving both the neurosurgery and neurology departments to enhance collaboration and optimize patient care.

Patients and Methods:

This study was designed as a prospective clinical study, conducted at Cairo University Hospitals in Egypt. All surgical procedures were performed within the study period from May 2022 to February 2023.

Method of Study

The study included patients diagnosed with movement disorders such as Parkinson's disease, dystonia, and essential tremors, who met the pre-established inclusion criteria. Eligible patients were offered deep lesioning procedures, including thalamotomy, pallidotomy, or a combination of both, based on feasibility and economic factors. All patients who accepted the procedure were included in the study.

Patient Selection

During the study period, 56 patients with movement disorders were evaluated at the outpatient clinic. However, only 24 met the selection criteria and were considered suitable for surgical intervention to control their motor symptoms. Among these, three patients refused surgery, leaving a final cohort of 21 patients.

General Considerations

All cases presented with idiopathic Parkinson's disease (IPD), essential tremors (ET), or dystonia and met the inclusion and exclusion criteria. A combined evaluation was conducted by a specialized neurologist and neurosurgeon, involving general neurological examinations and imaging studies, including CT and MRI, with video documentation of tremors and selected neurological assessments. The neurologist's role was to establish an accurate diagnosis, review the patient's medication history, and assess any complications related to medical treatment. The neurosurgeon evaluated surgical fitness, discussed expectations and realistic outcomes with the patient and their family, and determined the appropriate target for intervention. Objective assessments were performed using standardized scales such as the Unified Parkinson's Disease Rating Scale (UPDRS) for Parkinson's patients, the Unified Dystonia Rating Scale (UDRS) for dystonia patients, and the Essential Tremor Rating Assessment Scale (TETRAS) for essential tremor patients, both preoperatively and postoperatively, to ensure accurate outcome measurement.

Specific Considerations

The inclusion criteria varied based on the type of movement disorder. For Parkinson's disease, patients were eligible if they had idiopathic Parkinson's disease for at least five years, experienced severe medication-refractory motor fluctuations, levodopa-induced dyskinesias, disabling medication-resistant tremors, or marked medication intolerance (UPDRS-III scores of 30 or higher). Patients over 70 years old or those with psychiatric symptoms indicative of impending dementia were excluded. For dystonia, eligibility was limited to patients with primary generalized dystonia or disabling focal dystonia who were refractory to medical treatments, including anticholinergics, baclofen, benzodiazepines, and botulinum toxin. The age limit for dystonia patients was set at 75 years. For essential tremors, patients were included if they had failed medical management and exhibited resting

or disabling distal tremors. Those older than 75 years, with a history of severe head injury, prior cranial surgeries, or infections, were excluded from the study.

Sample Size

The sample size was determined using statistical analysis based on the paired t-test. The required number of participants in each group was calculated to be 20, with an additional 5% dropout rate anticipated, resulting in a final sample size of 21 participants per group. Data were coded and analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA), with results summarized using mean and standard deviation for quantitative variables. A paired t-test was used to compare preoperative and postoperative data, and a P-value of less than 0.05 was considered statistically significant.

Pre-Treatment Assessment

A comprehensive preoperative assessment was conducted, including a detailed history-taking process that documented demographic data such as sex, age, occupation, smoking habits, and comorbid medical conditions. Past medical history was obtained to identify chronic illnesses such as diabetes, hypertension, chronic renal or liver diseases, cardiac issues, and previous neurological conditions. A surgical history review included any prior trauma or operations. The onset of the disease, time of diagnosis, and medication history were also recorded, with special attention to levodopa-induced dyskinesias, motor fluctuations, daily levodopa-equivalent doses (LDED), and types of medications used.

Neurological examinations assessed disease severity using the Movement Disorder Society's Unified Parkinson's Disease Rating Scale (MDS-UPDRS) for Parkinson's disease, the Modified Hoehn and Yahr (H&Y) staging, and the Schwab and England Activities of Daily Living Scale. For essential tremor patients, the TETRAS scale was applied, while the UDRS was used for dystonia patients. These assessments were performed both preoperatively and postoperatively to evaluate clinical improvement.

Imaging Studies

Preoperative imaging included MRI scans to rule out secondary pathology. High-resolution T1 and T2 MRI sequences in DICOM format were obtained to precisely visualize the anterior-posterior commissure (AC-PC) reference and target regions.

Surgical Technique

On the night before surgery, all antiparkinsonian medications were withheld to allow for intraoperative and immediate postoperative assessments. The surgical process began with the application of a stereotactic frame under local anesthesia and short-acting sedation using propofol. Special care was taken to ensure that the frame was balanced, and the frontal pins were correctly positioned to avoid the supraorbital nerve and vessels.

A high-resolution CT scan was obtained with fiducial markers to facilitate fusion with MRI images. Using a target planning software (MayPoint Viewer, FHC Co., USA), the AC-PC plane was localized, and the optimal surgical target was determined. Atlas-based targeting, with modifications based on individual patient anatomy, was employed using Anne Morel's atlas.

For Vim targeting, the coordinates were set at 12–14 mm lateral to the midline, 6 mm anterior to the PC point, and 0–1 mm superior to the mid-commissural plane. The GPi target was positioned at 20–21 mm lateral to the midline, 2–3 mm anterior to the mid-commissural point, and 4–5 mm below the mid-commissural plane.

The selected entry point was chosen through the crown of a gyrus, typically around 3 cm lateral to the midline and just anterior to the coronal suture (Kocher's point). Once the target was finalized, the

coordinates were measured using the target planning software, and phantom verification was performed to confirm accuracy before proceeding with the surgical trajectory.

Surgical Procedure and Postoperative Imaging

The patient was placed in a supine position with chest elevation, and under local anesthesia and strict aseptic conditions, a skin incision was made at the selected entry point. A burr hole was created, and macrostimulation was performed using the Neuro N50 lesion generator (Inomed Instruments, Emmendingen, Germany). The electrode used for lesioning was a 1.8 mm bipolar transcranial probe with a 2 mm uninsulated tip.

Postoperatively, an axial CT scan was obtained to rule out complications and confirm the location of the lesion.

Postoperative Follow-Up Evaluation

Patients were evaluated at multiple time points: immediately after surgery, three months postoperatively, and six months postoperatively. Outcome assessments included MDS-UPDRS, Modified Hoehn and Yahr staging, Schwab and England Activities of Daily Living Scale, and PDQ for Parkinson's patients. The TETRAS scale was used for essential tremor patients, while the UDRS was applied for dystonia patients. These assessments ensured objective evaluation of symptom improvement and the effectiveness of the lesioning procedures.

Statistical analysis

Microsoft Excel 2013 was used for data entry, while data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 24 (SPSS, Armonk, New York: International Business Machines Corporation). Descriptive statistics were applied to summarize the collected data. Quantitative data were expressed using arithmetic means and standard deviations, while medians and ranges were used for data that did not follow a normal distribution. Qualitative data were presented as frequencies and percentages. To assess bivariate relationships, cross-tabulations were used for categorical variables. Comparisons of proportions between groups were conducted using the chi-square test, and Fisher's exact test was applied when appropriate for smaller sample sizes. For the comparison of abnormally distributed quantitative data, the Mann-Whitney test was performed to determine statistical significance. The threshold for statistical significance was set at a probability (P) value of less than 0.05. Any results with a P-value below this threshold were considered statistically significant, indicating a meaningful difference between the compared groups.

Results

This study was designed as a prospective clinical investigation, including 21 patients diagnosed with movement disorders such as Parkinson's disease (PD), essential tremors (ET), and dystonia. All patients were refractory to medical treatment and met the established inclusion criteria. The primary objective of this study was to assess the outcomes of lesioning procedures in these patients.

The patients were categorized into three distinct groups based on their specific movement disorder. Sixteen patients were included in the PD group, three patients in the ET group, and two patients in the dystonia group.

Regarding demographic data, the mean age varied among the groups. The mean age in the PD group was 61.3 years with a standard deviation of ±7.6 years. In the ET group, the mean age was 35.6 years with a standard deviation of ±15.5 years, while the dystonia group had a mean age of 25.5 years with a standard deviation of ±0.7 years. The gender distribution revealed that 93.8% of the PD group were male, 66.7% of the ET group were male, and all patients in the dystonia group were male.

The choice of lesioning procedure was determined by the predominant symptoms of each patient. Thalamotomy alone was performed in patients with tremor-predominant Parkinson's disease,

characterized by minimal rigidity or bradykinesia, as well as in patients with essential tremors. Pallidotomy alone was performed in patients with L-dopa-induced dyskinesia, bradykinesia-predominant Parkinson's disease, or rigidity-predominant Parkinson's disease, as well as in patients with dystonia.

The classification of patients into tremor-predominant or rigidity-predominant subtypes was based on the patient's primary complaint and the Unified Parkinson's Disease Rating Scale (UPDRS) motor subsets. In cases where patients exhibited combined symptoms, a combined approach involving both pallidotomy and thalamotomy was performed. This combined procedure targeted the ventral intermediate nucleus (Vim) and the globus pallidus internus (GPi) on the same side, addressing a broader range of motor dysfunction.

Table 1 showing different targets according to symptomatology

Symptom	Target
Tremors	(Vim) Thalamotomy
Rigidity & bradykinesia	(GPi) Pallidotomy
Combined	Vim & GPi

There was insignificant difference among the three groups as regard duration, main side affected and thalamotomy. Age was significantly higher in PD group than ET group and Dystonia group (P value<0.05) while insignificantly different between ET group and Dystonia group. Main symptoms and pallidotomy were significantly different among the three groups.

Table (2): Basic clinical and demographic characteristics of study participants.

	PD (n=16)	ET (n=3)	Dystonia (n=2)	p-value
Gender Male Female	15 (93.8%) 1 (6.3%)	2 (66.7%) 1 (33.3%)	2 (100%) 0 (0%)	0.304 [a]
Age (Mean ±SD) in years	61.3±7.6 [*,#]	35.6±15.5[*]	25.5±0.7 [#]	**<0.001[b]**
Duration (Median, range) in years	5.5 (2-10)	5 (3-20)	9 (8-10)	0.346 [c]
Main Side Affected Bilateral more Lt side. Bilateral more Rt side. Right. Left. Left tremors and right rigidity.	3 (18.8%) 4 (25%) 5 (31.3%) 3 (18.8%) 1 (6.3%)	0 (0%) 1 (33.3%) 0 (0%) 2 (66.7%) 0 (0%)	1 (50%) 1 (50%) 0 (0%) 0 (0%) 0 (0%)	0.555 [a]
Thalamotomy Bilateral Left Right	4 (25%) 5 (31.3%) 4 (25%)	1 (33.3%) 0 (0%) 2 (66.7%)		0.121 [a]
Pallidotomy Bilateral Left Right	1 (6.3%) 2 (12.5%) 4 (25%)		2 (100%) 0 (0%) 0 (0%)	**0.17** [a]
Main symptoms -Rigidity.	2 (12.5%)			

-Rigidity and drug induced dyskinesia. -Tremors. -Tremors and rigidity.	1 (6.3%) 9 (56.3%) 4 (25%)			**0.01** [a]

*Significant as P value≤0.05, a: Chi-square test. b: One way ANOVA test. *,#: Post hoc Bonferroni test showing difference between groups having same symbol. c: Kruskal Wallis test.

UPDRS II, UPDRS III, tremors, rigidity, akinesia and PIGD off/on periods and UPDRS IV, Modified H&Y and PDQ were significantly lower postoperative compared to preoperative (P value<0.05). Schwab and England was significantly higher in postoperative compared to preoperative (P value<0.001).

Table (3): Assessment scores measured preoperative and postoperative among PD patients.

Mean ±SD/ Median, IQR	Preoperative	Postoperative	% of improvement	p-value
UPDRS II off	32.6±4.9	13.7±3.3	57.5%	**<0.001***
UPDRS II on	28.8±4.6	11.7±2.9	58.9%	**<0.001***
UPDRS III off	30.4±7	16.4±4.3	46.3%	**<0.001***
UPDRS III on	21±5.4	8.8±2.4	57.7%	**<0.001***
UPDRS IV	15.2±2.3	8.25±2.5	46.2%	**<0.001***
Tremors off	6.0 (5.0-7.0)	2.0 (2.0-3.0)	60%	**0.001 #**
Tremors on	4.0 (3.0-4.0)	1.0 (0.0-1.0)	75%	**0.001 #**
Rigidity off	2.5 (2.0-3.0)	1.0 (1.0-2.0)	50%	**0.001 #**
Rigidity on	2.0 (1.0-2.0)	1.0 (0.25-1.0)	50%	**0.007 #**
Akinesia off	12.9±3.04	6.9±2.05	46.7%	**<0.001***
Akinesia on	9.06±2.2	3.25±1.0	63.8%	**<0.001***
PIGD off	8.0±2.3	4.12±1.7	49.4%	**<0.001***
PIGD on	5.3±1.8	2.06±1.2	62.3%	**<0.001***
Modified H&Y	3.19 (2-4)	1.63 (1-2)	54.16%	**<0.001 #**
Schwab and England	46.9 (40-60)	77.5 (72.5-90)	60.04%	**<0.001 #**
PDQ	57.12±15.4	28.25±7.2	49.3%	**<0.001***

*Significant as P value≤0.05, *: Paired samples T test. #: Wilcoxon signed rank test.

In PD group, Complications were mild dysarthia in 3 (18.75%)patients and RT ASDH & LT sided weakness in 1 (6.25%) patient.

Table (4): Complications occurred among PD patients.

	Frequency, %
Mild Dysarthia	3 (18.75%)
RT ASDH & LT sided weakness	1 (6.25%)

In ET group:

TETRAS score off/on periods was significantly lower postoperative compared to preoperative (P value=0.011 and 0.003 respectively). Percentage of improvement of TETRAS off was 41.5% and percentage of improvement of TETRAS on was 30.3%.

Table (5): **Assessment scores measured preoperative and postoperative among ET patients.**

Mean ±SD/ Median, IQR	Preoperative	Postoperative	% of improvement	p-value *
TETRAS off	26.3±2.5	15.3±0.57	41.5%	**0.011**
TETRAS on	18.7±1.5	13.0±1.0	30.3%	**0.003**

*: Paired samples T test.

In Dystonia group:

UDRS score was significantly lower postoperative compared to preoperative (P value=0.033). Percentage of improvement was 41.5%.

Table (6): **Assessment scores measured preoperative and postoperative among Dystonia patients.**

Mean ±SD/ Median, IQR	Preoperative	Postoperative	% of improvement	p-value *
UDRS	12.25±1.06	7.5±0.7	41.5%	**0.033**

*: Paired samples T test.

Case 1: R.A.A. was a 69-year-old right-handed male patient with a long-standing history of idiopathic Parkinson's disease, initially diagnosed eight years prior. His symptoms were predominantly tremor-related, affecting both sides but more significantly on the right. Three years before the current intervention, he had undergone a left-sided thalamotomy using stereotactic radiofrequency ablation to manage his symptoms.

The patient had started antiparkinsonian medications, including Sinemet and Ramixole, at the time of diagnosis, which initially provided symptomatic relief. However, after two years, the effectiveness of the medications declined, necessitating an increase in dosage and subsequent changes in the medication regimen to maintain symptom control. His medical history was notable for benign prostatic hyperplasia, for which he was on tamsulosin. Preoperative assessment revealed that his UPDRS II score during the Off period was 38, improving to 32 during On periods. His UPDRS III score was 48 in the Off period and 38 in the On period. Akinesia was scored at 10, and postural instability and gait disturbance (PIGD) were recorded as 3. The Modified Hoehn & Yahr staging scale classified him at stage 3. His Parkinson's Disease Questionnaire (PDQ) score was 34, while the Schwab and England Activities of Daily Living Scale measured his functional independence at 40%. Tremor severity was rated as 3 during both the Off and On periods. Preoperative imaging was performed to localize the target of interest and define the optimal surgical trajectory. In this case, right-sided ventral intermediate nucleus (VIM) targeting was planned for intervention.
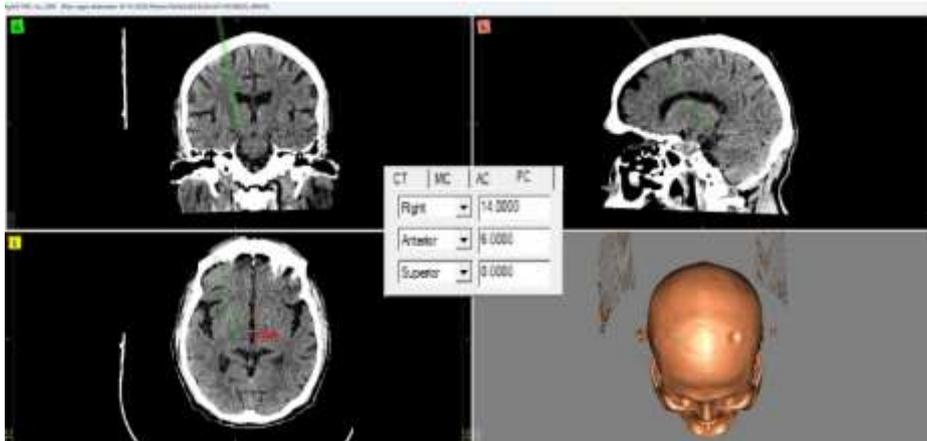
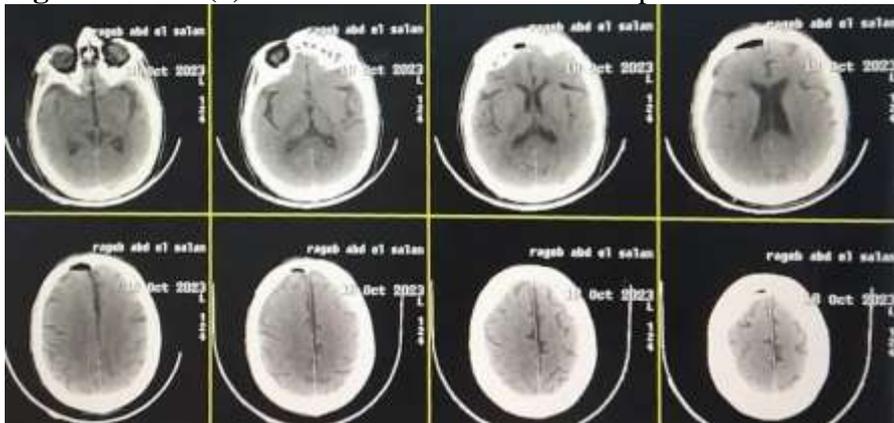**Fig   (1):   Pre-operative   localization   imaging**

Fig (2): Post-operative imaging

Following the surgical intervention, the patient showed significant improvement in his motor function and overall quality of life. The UPDRS II score decreased from 38 in the Off period to 18, and from 32 to 14 in the On period. Similarly, the UPDRS III score improved from 48 in the Off period to 24, and from 38 to 20 in the On period.

There was a noticeable reduction in akinesia, which decreased from 10 to 6, while postural instability and gait disturbance (PIGD) improved from 3 to 2. The Modified Hoehn & Yahr staging scale showed an improvement, moving from stage 3 preoperatively to stage 2 postoperatively. The Parkinson's Disease Questionnaire (PDQ) score improved from 34 to 20, reflecting a better perception of health-related quality of life. The Schwab and England Activities of Daily Living Scale also showed marked improvement, rising from 40% to 70%, indicating enhanced functional independence.

Tremor severity was significantly reduced, with a postoperative rating of 1 during both the Off and On periods, compared to 3 before surgery. The only observed complication was mild dysarthria, which did not significantly impact the patient's daily activities. Overall, the procedure resulted in substantial symptomatic relief and functional improvement.

Case No. 2

L.M. was a 55-year-old right-handed male patient diagnosed with idiopathic Parkinson's disease six years prior. His symptoms were predominantly tremor-related, affecting both sides but more pronounced on the right. Over time, he experienced a progressive worsening of symptoms despite pharmacological treatment. He had been prescribed Sinemet, Achtenon, and Ramixole, which initially provided partial improvement, but their efficacy declined as the disease progressed. His medical history was otherwise unremarkable.

Preoperative assessment revealed that his UPDRS II score during the Off period was 36, with a slight improvement to 34 during the On period. His UPDRS III score was 46 in the Off period and 40 in the On period. Akinesia was rated at 7, while postural instability and gait disturbance (PIGD) were recorded as 4. The Modified Hoehn & Yahr staging scale classified him at stage 4, indicating significant disability. His Parkinson's Disease Questionnaire (PDQ) score was 44, reflecting a lower quality of life. The Schwab and England Activities of Daily Living Scale measured his functional independence at 50%, indicating moderate dependence on assistance for daily activities. Tremor severity was rated as 3 during both the Off and On periods.

Preoperative imaging was performed to determine the optimal trajectory for surgical intervention. In this case, left-sided ventral intermediate nucleus (VIM) targeting was planned as the primary lesioning approach.
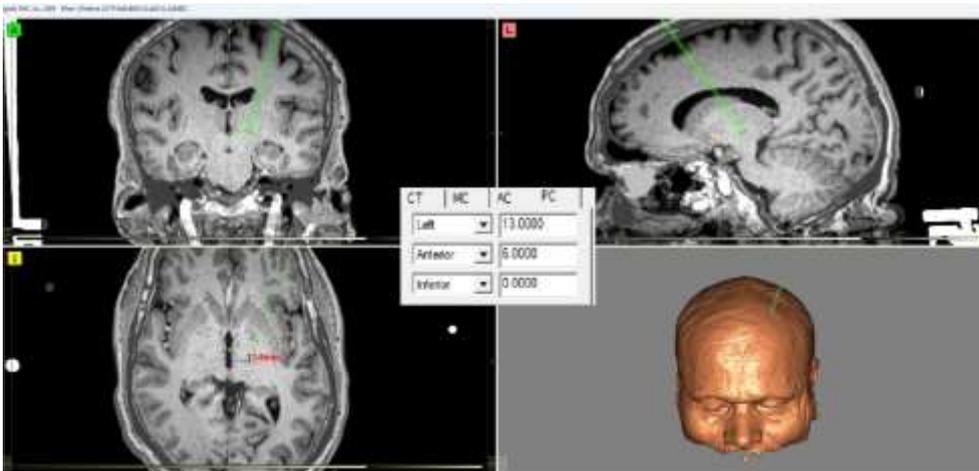

Fig (3): Pre-operative localization imaging

Fig (4): Post-operative imaging

Following the surgical intervention, the patient demonstrated significant clinical improvement in motor function and overall quality of life. The UPDRS II score decreased from 36 in the Off period to 18, and from 34 to 12 in the On period. Similarly, the UPDRS III score showed marked improvement, decreasing from 46 in the Off period to 24, and from 40 to 16 in the On period.

Akinesia was reduced from 7 to 5, while postural instability and gait disturbance (PIGD) improved from 4 to 2. The Modified Hoehn & Yahr staging scale improved from stage 4 preoperatively to stage 2 postoperatively, reflecting a significant reduction in disability. The Parkinson's Disease Questionnaire (PDQ) score improved from 44 to 21, indicating an enhanced perception of health-related quality of life. The Schwab and England Activities of Daily Living Scale showed considerable progress, improving from 50% to 70%, which signified a higher level of functional independence.

Tremor severity also showed a notable decrease, with a postoperative rating of 2 during both the Off and On periods compared to the preoperative rating of 3. Importantly, no complications were reported postoperatively, indicating a smooth recovery and a successful outcome.

Case No. 3

This case involved a 59-year-old right-handed male patient diagnosed with idiopathic Parkinson's disease seven years ago. His symptoms were characterized by predominant tremors and rigidity affecting both sides, with a greater severity on the left side. Despite being on a medical regimen that included Sinemet, Inderal, and Ramixole, his initial partial improvement declined over time, leading to worsening motor symptoms. His medical history was significant for diabetes mellitus.

Preoperative assessment revealed that his UPDRS II score during the Off period was 40, improving slightly to 36 during the On period. His UPDRS III score was 42 in the Off period and 38 in the On period. Akinesia was rated at 8, while postural instability and gait disturbance (PIGD) were recorded as 3. The Modified Hoehn & Yahr staging scale classified him at stage 3, indicating moderate disability. His Parkinson's Disease Questionnaire (PDQ) score was 54, reflecting a significant impact on his quality of life. The Schwab and England Activities of Daily Living Scale measured his functional independence at 50%, indicating a moderate level of dependency.

Rigidity was notably severe, rated at 4 in the Off period, improving to 2 in the On period. Tremor severity was rated as 3 in both the Off and On periods. Given his combined presentation of rigidity and tremors, a right-sided globus pallidus internus (GPi) and ventral intermediate nucleus (VIM) targeting approach was planned to provide optimal symptomatic relief.

Postoperative Follow-Up and Assessment

Following the lesioning procedure, the patient exhibited significant improvements in motor function and daily living activities. The UPDRS II score improved from 40 in the Off period to 20, and from 36 to 14 in the On period. Similarly, the UPDRS III score decreased from 42 to 24 in the Off period and from 38 to 20 in the On period, reflecting enhanced motor performance.

Akinesia improved from 8 to 5, while postural instability and gait disturbance (PIGD) improved from 3 to 2. The Modified Hoehn & Yahr staging scale showed an improvement from stage 3 to 2, indicating a reduction in disability. His Parkinson's Disease Questionnaire (PDQ) score improved from 54 to 30, indicating a better perception of quality of life. The Schwab and England Activities of Daily Living Scale increased from 50% to 75%, demonstrating improved functional independence.

Rigidity showed significant improvement, reducing from 4 in the Off period to 1, and from 2 in the On period to 0 postoperatively. Tremor severity also improved, decreasing from 3 in both the Off and On periods to 1 postoperatively. The procedure resulted in substantial symptom relief, and no complications were reported during the postoperative period.

Following surgery, the patient was fully conscious but exhibited left-sided weakness with motor power graded at 4. He remained vitally stable; however, he was hyperglycemic and managed with insulin therapy.

On the third postoperative day, the patient developed status epilepticus and was admitted to the ICU. He was intubated and placed on mechanical ventilation for airway protection. During this period, his

motor power on the left side worsened, decreasing to grade 2. His hyperglycemia persisted, requiring insulin infusion for stabilization. A CT brain scan was performed to assess potential postoperative complications.

Four days later, the patient's seizures were controlled, and he was successfully extubated. He regained full consciousness but continued to have left-sided weakness with motor power still graded at 2. His vital signs were stable, and blood glucose levels normalized with insulin management. He was discharged from the ICU to the ward, and a follow-up CT brain scan was conducted before he was discharged home two days later.

Postoperative Follow-Up and Assessment

The patient's UPDRS II score in the Off period improved from 40 preoperatively to 23, and from 36 to 21 in the On period. His UPDRS III score also showed significant improvement, decreasing from 42 to 24 in the Off period and from 38 to 16 in the On period. Akinesia improved from 8 to 5, while postural instability and gait disturbance (PIGD) improved from 3 to 2.

The Modified Hoehn & Yahr staging scale showed an improvement from stage 3 preoperatively to 2 postoperatively, reflecting a decrease in disease severity. His Parkinson's Disease Questionnaire (PDQ) score improved from 54 to 33, indicating a better quality of life. The Schwab and England Activities of Daily Living Scale increased from 50% to 70%, reflecting greater functional independence.

Rigidity showed significant improvement, decreasing from 4 to 1 in the Off period and from 2 to 1 in the On period. Tremors were also well controlled, with a reduction from 3 preoperatively to 1 postoperatively in both Off and On periods.

Complications

The patient developed a right-sided acute subdural hematoma (ASDH) as a postoperative complication, which contributed to his left-sided weakness. Initially, motor power in the left side was grade 2, but with intensive physical therapy and rehabilitation, it gradually improved to grade 4 over the follow-up period. Despite these complications, the patient achieved overall motor and functional improvement.
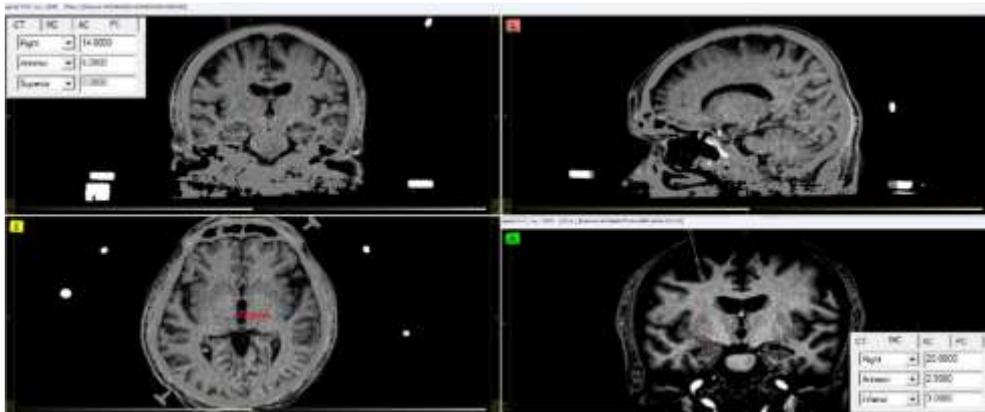

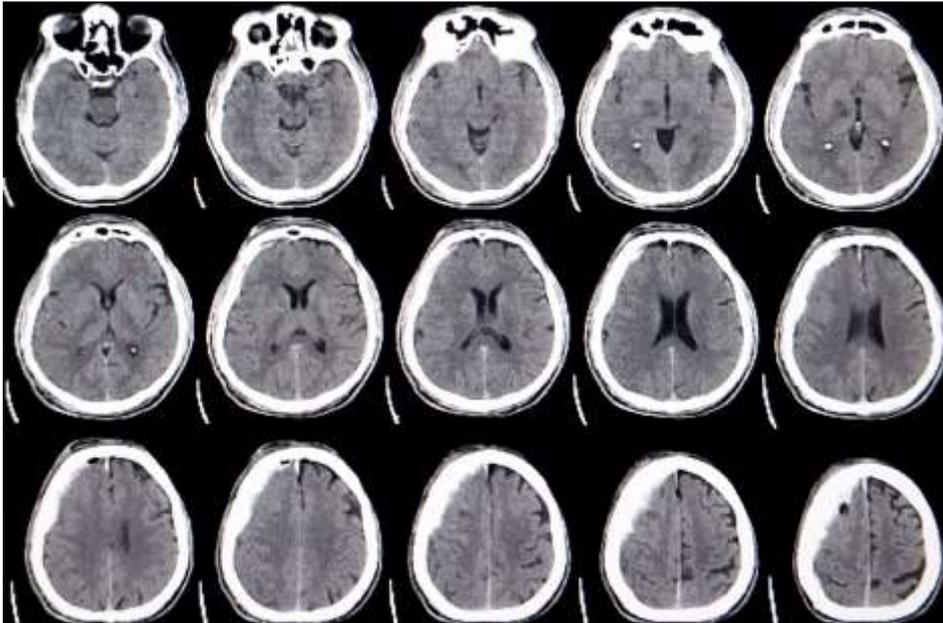**Fig (5):** Pre-operative localization imaging
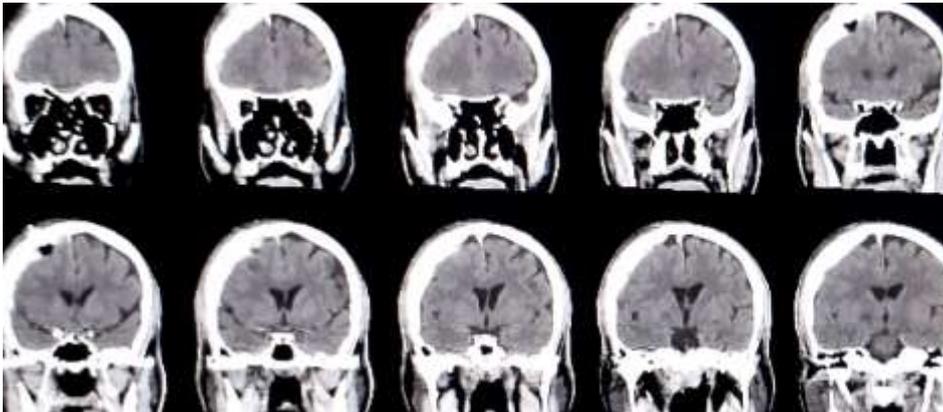
Fig (6): Immediate Post-operative CT brain

Fig (7): Immediate Post-operative CT brain
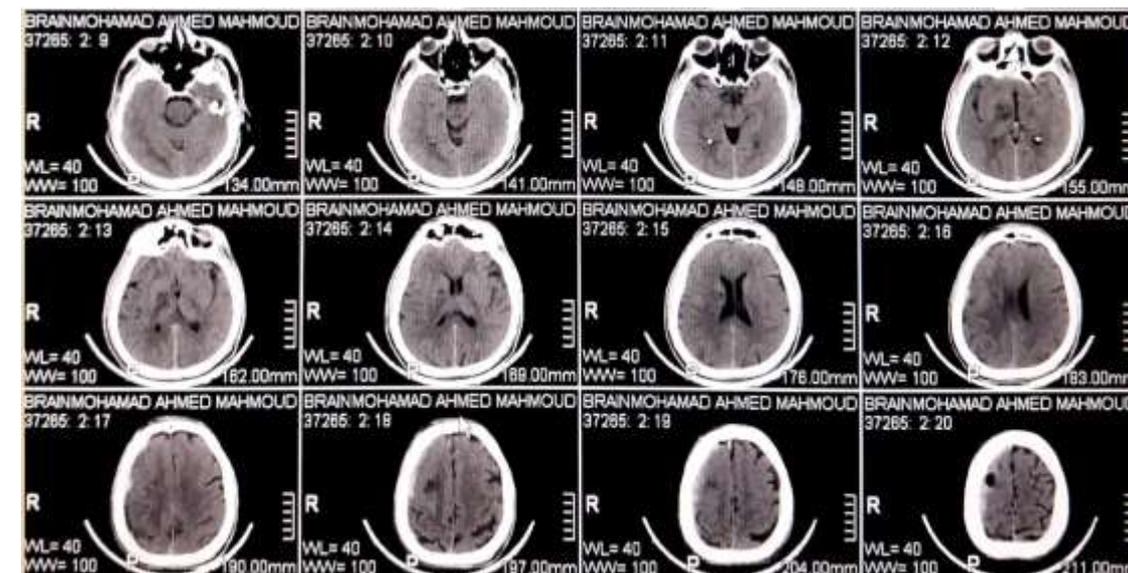

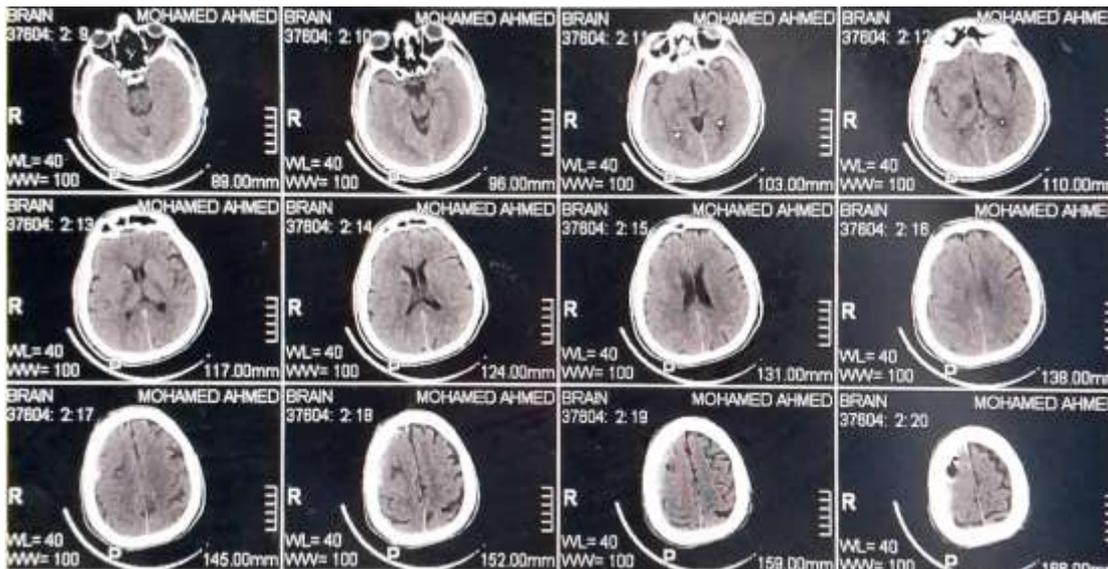**Fig (8):** post status epilepticus CT brain

Fig (9): FU CT brain before discharge

Discussion:

Movement disorders are neurological syndromes in which there is either an excess of movement (hyperkinesia) or a paucity of voluntary and involuntary movements (hypokinesia), unrelated to weakness or spasticity (Patel et al. [6]). Movement disorders are traditionally linked to basal ganglia or extrapyramidal diseases but can also involve the cerebellum. Movement disorders are conventionally divided into two major categories: hyperkinetic and hypokinetic (Ortigoza-Escobar [7]).

Hyperkinetic movement disorders refer to dyskinesia, or excessive, often repetitive, involuntary movements that intrude upon the normal flow of motor activity. Hypokinetic movement disorders refer to akinesia (lack of movement), hypokinesia (reduced amplitude of movements), bradykinesia (slow movement), and rigidity. Parkinson's disease is an example of a hypokinetic movement disorder (Sanger et al. [8]).

Parkinson's disease (PD) is a movement disorder that is the second most common neurodegenerative disease (Kulcsarova and Skorvanek [9]). Over one million Americans currently live with PD, and ~60,000 patients are newly diagnosed each year. Furthermore, the incidence of PD is only expected to increase in the coming decades (Saini et al. [10]).

Stereotactic neurosurgical procedures provided surgeons with more effective methods of treating PD with lower morbidity and mortality than in earlier eras. With the rediscovery of the potential benefits of surgery, ablative neurosurgical procedures of PD have experienced a renaissance since the 1980s (Chao et al. [11]).

This prospective clinical study on 21 patients with an age of 70 years or less with refractory IPD either complaining of tremors or rigidity, Levodopa-associated dyskinesias in parkinsonian, medically refractory tremors, and primary dystonia. The patients were divided into three groups according to movement disorders: PD group (n=16), ET group (n=3), and Dystonia group (n=2).

In the present study, the mean value (±SD) of age was 61.3 (±7.6) years in the PD group, 35.6 (±15.5) years in the ET group, and 25.5 (±0.7) years in the Dystonia group. There were 15 (93.8%) males in the PD group, 2 (66.7%) males in the ET group, and all patients were males in the Dystonia group. There was an insignificant difference among the three groups regarding duration, the main side affected, and thalamotomy. Age was significantly higher in the PD group than in the ET and Dystonia

groups while insignificantly different between the ET and Dystonia groups. Main symptoms and pallidotomy were significantly different among the three groups.

There is evidence that tremor is pathophysiologically disconnected from bradykinesia and rigidity (Hallett [12]). Clinically, the manifestations are separate, and the response of tremor to dopaminergic agents is less certain than bradykinesia, first demonstrated that marked clinical diversity exists in PD, and later studies provided experimental and clinical support for the PD subgroup differences. Further factor analysis of PD signs showed that rest tremor was relatively independent of other cardinal signs of PD (Milosevic et al. [13]), was less reliably responsive to dopaminergic modulation, and did not worsen at the same rate as bradykinesia and rigidity (Rajput et al. [14]).

The underlying pathophysiology of these disorders plays a significant role in the age of onset and progression. Hypokinetic disorders are primarily age-related and associated with the gradual degeneration of neurons over time, leading to a higher average age in this group. Conversely, hyperkinetic disorders, such as ET and Dystonia disease, are often inherited or caused by developmental abnormalities, resulting in an earlier onset and a lower average age in this group (DeMaagd and Philip [15]).

In our result, there was significant improvement in UPDRS II by 57.5% and 58.9% in the Off and On periods respectively, UPDRS III by 46.3% and 57.7% in the Off and On periods respectively, akinesia by 46.7%, PIGD by 49.4%, UPDRS IV by 46.2%, Modified Hoehn & Yahr staging scale improved by 54.16%, PDQ by 49.3%, Schwab and England score improved by 60.04%. There was a dramatic improvement in rigidity and tremor by 50% and 60% respectively in the Off period and by 50% and 75% respectively in the On period, in postoperative compared to preoperative in PD patients.

Regarding the thalamotomy group, unilateral thalamotomy was done in 56.3% (31.3% on the left side and 25% on the right side) of our total PD patients while bilateral thalamotomy was done only in 25% of them. Thalamotomy can produce cessation or significant improvement in contralateral tremor. It also can produce considerable improvement in other contralateral cardinal symptoms of PD. It also can decrease L-Dopa-induced dyskinesia and improve the quality of life of PD patients.

Regarding the pallidotomy group, unilateral pallidotomy was done in 37.5% (12.5% on the left side and 25% on the right side) of our total PD patients while bilateral pallidotomy was done only in 25% of them. Pallidotomy can improve the cardinal symptoms of PD. It also can decrease the complications of L-Dopa and improve the quality of life of PD patients.

Lozano & Lang [16] study showed that pallidotomy improved UPDRS II and UPDRS III by 31% and 30% retrospectively in the Off period. The improvement in rigidity, body bradykinesia, and PIGD was 30%, 22%, and 23% retrospectively in the Off period. Tremor was not prominent in patients here, so it was not assessed. Schwab & England ADL score improved by 50% in the Off period. Dyskinesia reduced by 92% in the On period.

In Merello et al. [17] study, which compared pallidotomy with GPi DBS, the results of the pallidotomy group showed improvement in rigidity, body bradykinesia, tremors, and PIGD by 77.6%, 36%, 44%, and 37.2% retrospectively in the Off period. These results are similar to the results of our study.

In Vitek et al. [18] study, which compared pallidotomy with medical treatment in PD, the results of the pallidotomy group showed improvement in UPDRS II and UPDRS III by 23% and 32% retrospectively in the Off period. The improvement in rigidity and tremor was 55% and 71% retrospectively in the Off period. A significant improvement in PIGD was noticed by 33% in the Off period. Dyskinesia reduced by 75% in the On period. Schwab & England ADL score improved by 30% in the Off period. The Modified H & Y staging scale improved by 22% in the Off period. The results of this study are similar to the results of our study.

There are just a few studies in the literature for the assessment of thalamotomy outcomes in PD. These studies are mainly interested in the effect of thalamotomy on tremor and dyskinesia.

In Jankovic et al. [19] study, thalamotomy had a significant improvement of contralateral tremor, up to the abolition of contralateral tremor in some patients. Rigidity and bradykinesia improved by 30% and 14.29% in the Off period. Patients who had dyskinesia preoperatively showed considerable improvement in dyskinesia.

In Narabayashi et al. [20] study, there was a significant improvement in L-Dopa-induced dyskinesia in 13 patients who had preoperative dyskinesia and underwent thalamotomy.

Results of Duval et al. [21] study showed that thalamotomy had a significant improvement in contralateral tremor. It reduced tremor amplitude by selectively targeting centrally driven components of PD tremor.

In Nijhawan et al. [22] study, the results showed improvement in UPDRS II and UPDRS III by 8.25% and 21.58% in the Off period retrospectively and by 22.22% and 4.74% in the On period retrospectively. Hoehn and Yahr improved by 8.33% in the On period and showed no improvement in the Off period. There was a significant improvement in tremor and activities of daily living.

To compare our results with DBS results, in Volkmann et al. [23] study, six patients (from an initial cohort of 11 individuals) experienced improvements in UPDRS part III scores in Off periods that were maintained at 3 years (a reduction of 43%), but the only remaining benefit by 5 years was an improvement in rigidity. Four of the original 11 patients who lost an initial benefit from GPi DBS subsequently underwent STN DBS, which renewed their improvement. In patients who continued to receive GPi DBS, beneficial effects on levodopa-induced dyskinesia were maintained up to 5 years. These results are similar to the results of our study.

In contrast to these generally negative findings, in Moro et al. [24] study of 16 patients, UPDRS part III scores in the Off period were reduced by GPi DBS from a mean baseline of 52.2 to a mean of 33.9, even after 5–6 years of the treatment.

The public healthcare system in developing countries, in contrast to high-income countries, does not finance DBS implantation; therefore, the majority of the patients are limited to lesion therapy. When we compare the price of the procedures versus the functional outcome achieved, however, it is possible to realize that pallidotomy remains an efficient and safe therapeutic option. It is true not only for those patients that cannot afford health insurance or surgery but also for the ones that are unsuitable to perform DBS surgery, such as HIV and immunocompromised patients, those with major comorbidities, and those who are not able to be followed up on. It is important to mention that we are not saying that pallidotomy is superior to DBS surgery, but instead, it represents a more cost-effective option and is not as feasible for all patients around the world. Instead, we claim that we should try to adapt the type of surgical therapy to each country's or place's reality and not abandon PVP only because it represents a lesion and irreversible therapy. Instead, we should consider decision-making based on individual cases without abandoning a procedure with real evidence that is well established in medical literature (Bruno Spindola et al. [25]).

Limitations

Limitations

This study had several limitations that should be acknowledged. One of the major limitations was the absence of a control population or a comparison with other treatment modalities. As a result, it was not possible to assess whether observed improvements were due to a placebo effect or natural disease progression. Additionally, financial constraints limited the ability to perform deep brain stimulation (DBS) surgeries for comparison or to use microelectrode recording (MER) for precise localization of the ventral intermediate nucleus (VIM) or globus pallidus internus (GPi). Instead, we relied on

macrostimulation guidance and somatotopic maps for localization, which, while effective, may not have provided the same level of accuracy as MER-guided approaches.

Another significant limitation was the relatively small sample size and short follow-up duration. While the study provided valuable insights into the outcomes of lesioning procedures in movement disorders, the limited number of patients may not provide solid evidence for the long-term efficacy of these treatment modalities. To obtain more definitive conclusions, future studies should consider larger sample sizes and extended follow-up periods to better assess the durability and sustainability of clinical improvements.

Additionally, the study did not explore alternative surgical targets, such as the subthalamic nucleus (STN) or the pedunculopontine nucleus (PPN), which have shown potential in both ablative and DBS surgeries for movement disorders. Investigating these targets could offer new insights into optimizing treatment outcomes. However, such an approach requires advanced expertise in stereotactic neurosurgery, which is not always readily available.

Finally, this was a single-center study, which may limit the generalizability of the findings. A multi-center study involving diverse patient populations and different surgical teams may yield more comprehensive results and help validate the efficacy of lesioning procedures across various clinical settings.

Conclusion

We conclude that lesioning procedure should be revisited globally using the modern techniques of targeting and controlled thermal lesion protocols guided by capsular somatotopy and intraoperative EMG monitoring, that will improve the outcome dramatically.

We recommend surgery for patients with Parkinson`s disease as soon as possible in case of refractory tremors, and we can wait for patient`s with rigidity and bradykinesia for a few years until side effects of L-Dopa medications appear. Lesioning procedure looks to be the best available option for the developing countries and countries without solid insurance system. Functional neurosurgery procedures and implanted devices have a huge cost burden on both the government and the patients in our country, but we should not abandon these interventions as they have a great effect on patients' quality of life. For essential tremor, thalamic vim stereotactic lesioning is considered the best surgical option if beta blockers fail to achieve tremor control. For dystonia, GPI stereotactic lesioning is considered good surgical option need for more studies to be proven. The data consider the unwanted effects of bilateral lesioning like cognitive dysfunction or speech deterioration needs more studies to prove it.

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