Longterm follow up of Deep brain stimulation versus lesioning in the treatment of Parkinson's disease: A single center study

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Abstract

Introduction: Parkinson's disease (PD) is a neurodegenerative disorder characterized primarily by loss of dopamine neurons in the Substantia Nigra Pars compacta resulting in various symptoms like bradykinesia, rigidity and tremor. Surgical treatments like lesioning procedure(Pallidotomy) and Deep brain stimulation surgery are well established surgical treatment for drug resistant PD
Materials & Methods: All the patients who underwent surgical treatment of Parkinsons Disease in Annapurna Neurological Institute And allied Sciences from 2016 January to December 2022 have been included in this study. Patients undergoing DBS versus lesioning in the treatment of Parkinson disease with more than two years follow up were reviewed retrospectively.
Results: Eighty cases were included in this study with 50 cases of Pallidotomy and 30 cases of DBS. The male to female ratio was 2:1 in both groups. There was no difference in mean duration of illness. However, the surgical timing, hospital stay and frequency of follow ups and surgical expenses were more in DBS group. Mean change in Unified Parkinsons Disease Rating Score (UPDRS) III at the immediately after surgery was 70 percent in Pallidotomy group and 65 % in DBS group(P=0.4). However it was not statisctically significant. In long term follow up period after two years, we found that the mean change in off period of UPDRS score in Lesioning vs DBS was 46.6 % vs 46.5% .(p=0.8)There was only 10 percent reduction on the dose of dopamine in pallidotomy group whereas there was 30 percent reduction in DBS group. Similarly there was significant reduction in Dyskinesia both in Pallidotomy and DBS group.
Conclusion: Both lesioning and DBS procedures are equally effective surgical treatment of Parkinsons Disease. Lesioning procedure are more feasible in our context due to its cost effectiveness and long term benefit.

Keywords: Deep Brain Stimulation DBS Lesioning Parkinsond Disease.

Introduction

Parkinson's disease (PD) is a neurodegenerative disorder characterized primarily by loss of dopamine neurons in the substantia Nigra Pars compacta. This was first explained by James parkinsons in 1871.[1] This depletion of dopamine disrupts modulatory control over striatal output pathways, manifesting clinically with hallmark motor symptoms such as akinesia or bradykinesia, muscular rigidity, and resting tremor.[2] PD is also associated with numerous non-motor symptoms, some of which precede the motor dysfunction by more than a decade.[3]

The mainstay of Parkinson's disease management is symptomatic treatment with drugs that increase dopamine concentrations or directly stimulate dopamine receptors.
When pharmacological management becomes inadequate or causes complications (e.g. dyskinesia), surgical interventions are considered.[4] The two principal neurosurgical modalities employed and deep brain stimulation (DBS) and Lesioning techniques, including pallidotomy, thalamotomy and subthalamotomy [4–6] DBS was pioneered and popularised by Benabid and colleagues in Grenoble in the late 1980s.[7] In recent years, a breakthrough strategy in the form of MRI-guided focused ultrasound (MRgFUS) has been pioneered with promising prospects.[8] Both neuromodulatory and ablative strategies represent the cornerstone of surgical

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management for the cardinal motor manifestations of Parkinson's disease. Since its advent, DBS is the most popular surgical choice in dealing with Parkinson's. Nonetheless, lesioning holds true as a therapeutic relevance, particularly for patients barred from DBS due to financial constraints or geographic restraints.[9] In addition, the revival of interest in minimally invasive ablative technologies, most notably, MR-guided focused ultrasound, has resurged the interest in lesioning as potential surgical treatment. Although several studies have demonstrated the high efficacy of lesioning on posteroventral nucleus of Gpi and STN DBS for Parkinson disease,[10,11]long term follow-up studies are very limited. Here we examined survival and long-term outcomes of PD patients treated with DBS and lesioning.

Materials and Methods

Standard protocol approval, registration, and patient consent

This study was approved by the medical ethics committee of Annapurna Neurological Institute and Allied Sciences. The medical ethics committee approved a waiver of consent for the collection of data as part of the routine clinical care and quality control.

Patient data

All the patients who underwent surgical treatment of Parkinsons Disease in Annapurna Neurological Institute and Allied Sciences from 2016 January to December 2022 have been included in this study. Patients undergoing DBS vs lesioning in the treatment of Parkinson disease were reviewed retrospectively. The medical and imaging records for all the patients were reviewed

Inclusion criteria: Patients who underwent surgical treatment of Parkinsons disease either Pallidotomy or DBS with more than two years follow up duration.

Exclusion criteria: Patients who underwent Pallidothalamic tract lesioning for PD has been excluded as it was started since 18 months only. Patient who are lost to follow up were also excluded.

Statistical test

Database was created in Microsoft excel and analysis was done in SPSS 19.0. Scalar variable was expressed in mean and standard deviation. Comparison of two parametric data was done by t-test. P value of <0.05 was considered significant.

Surgical procedures

All patients underwent Brain MRI (1.5-3 T, Philips) with no spacing and 3D Volume reconstruction image. It was retrieved in a DICOM CD. Then Stereotactic frame (Z-D Fisher) frame was applied and CT scan head was done (1 slice Siemens with 2 mm thickness) with no tilt. These images were retrieved in a DICOM CD. Then these two images were fused in the workstation and standard Globus palidus internus was visualized anatomically. The Anterior commisure(AC) and Posterior commisure(PC) was also visualized and AC- PC line was made. The standard functional targets were used for Globus pallidus internus.(2-3 mm infront of Midcommisural point, 20-22mm lateral to midline and 4-6 mm below ACPC line).

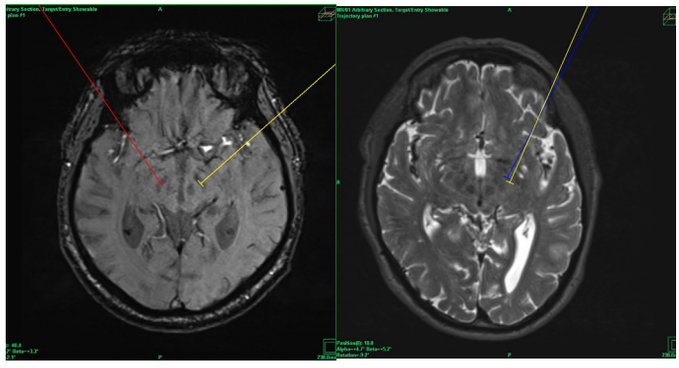

Figure: A) SWI Image showing STN DBS targeting

Figure: B)T2 axial imaging for Gpi DBS

The targets were also reverified by the inbuilt Schaltenbrand Atlas.Then the patients were taken to the operating room and the frame was fixed in the Mayfield C arm was also kept to reverify the target. Our surgical setup has been shown in figure 2. Under all aseptic precautions local anesthesia was given on the scalp and vertical incision was given (4 cm lateral to midline and 1 cm in front of coronal suture). A burr holes was created and dura was coagulated and cut and technique were used so as to prevent the loss of cerebrospinal fluid (CSF) thus brain shift is minimized. The thermal lesioning machine of Cosman RF generator/ N50 RF generator was used and the voltage, impedance and rate of the thermal coagulation were set. The lesioning electrode of 1 mm diameter and 2 mm exposed tip was used.

We used Cosman Radiofrequency probe with 0.75 mm internal diameter with 2 mm exposed tips. The permanent lesions were made at 75 degree centigrade for 60 seconds. We made four to five lesions in tandem fashion in the primary target and four lesions in secondary targets which is usually pasterolateral to previous targets. The targets were set and it was checked by C-arm. Usually the test dose of 50 degree centigrade for 30 sec was used and we made sure that there are no motor deficits. Then we made four lesions 1 mm apart in tandem fashion (75 degree centigrade for 60 second each.) in the primary target. Then we made four lesions similarly in the secondary targets which is usually posterolateral to the previous targets. Continuous communication to the patients was done to make sure that there is no motor symptoms and visual symptoms. Most of the cases of DBS were in Subthalamic Nucleus and few in Globus Pallidus Internus. We used the standard functional coordinates for STN and readjusted visually in SWI MRI images. (Figure 1).

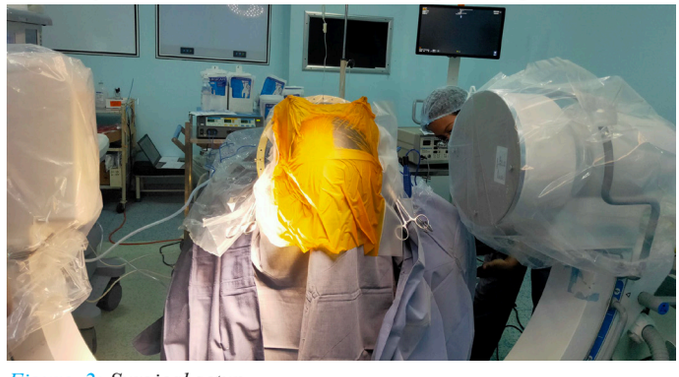

Figure 2: Surgical setup

In first ten cases we implanted St Judes DBS system and remaining other cases had Sceneray DBS. We did Microelectode recording (MER recording Inomed) in all cases of DBS but not in lesioning cases.

Evaluation:

Patients' demographics, duration of illness, dose of dopamir have been analysed. Unified parkinsons disease rating scor UPDRS) have been used both pre and postopaertaivel We used UPDRS II (ADL score) and UPDRS III for mot scoring was used. Postoperative change in UPDRS score in o phase have been analysed. In case of lesioning cases we us Postoperative UPDRS score at the time of discharge(At 5 da after surgery.) We used UPDRS score after 3 months of surge incase of DBS patients for immediate comparison. We al compared the UPDRS score after two years of the follow up.We also compared the surgical timing, expenses and complications of both the procedures.

Results

We have operated 130 cases of Parkinsons disease till March 2025. However, we have included 80 cases who met the inclusion criteria. Fifty cases had undergone Pallidotomy surgery out of which seventy percent were unilateral pallidotomy whereas thirty percent were stagged Pallidotmy. Out of 50 cases of Pallidotmy group ten cases also had add on Vim thalamotomy who had tremor dependent PD. Thirty cases had deep brain stimulation surgery out of which two cases were in GPi and remaining 28 cases were in STN.

The demographics of the cases have been compared as shown in table 1.

Table1: Demographic profile of PD Patients

Series	Lesioning	DBS	Remarks
Target	Gpi	Gpi/STN	
Site	Unilateral/ Stagged bilateral	Bilateral	
Number	50	30	
Mean Age±SD(years)	55.2 ±8.84	55.4 ±8.3	P=0.98
Male:Female ratio	2:1	2:1	
Mean duration of Illness±SD(years)	6.8±1.6	6 ±2.3	P=0.64
Surgical time (Hours)	1.5±0.5	5±1.1	P<0.05

The mean age of patients in pallidotomy group was 55.2 ±8.84 years and in DBS group was 55.4±8.3 years. The male to female ratio was 2:1 in both group. There was no difference in mean duration of illness.The mean duration of illness in pallidotomy was 6.8±1.6 years and in DBS was 6±2.3 years. There was statistical difference in the mean time of surgery with lesser time in pallidotomy group as it did not require general anesthesia. Similarly the hospital stay was more in DBS group .($p<0.05$)

The mean follow up in pallidotmy group and DBS group was 5.6± 1.6 years and 4.1±1.9 years respectively. The average follow up in DBS group was four to five times in a year whereas there was lesser follow up in pallidotomy group.

Mean change in ADL score immediately after surgery was 65% in lesioning and 60% in DBS group. Mean change in UPDRS score III at the immediately after surgery was 70 percent in Pallidotomy group and 65 % in DBS group.(p value:0.4).(Table 2)

Table 2: Result in term of change in UPDRS score

Series	Lesioning	DBS	Remarks
Mean Change in UPDRS II(ADL) at 3 months(%)	65	60	P=0.6
Mean Change in UPDRS II (ADL at 2 years (%)	40	45	P=0.9
Mean Change in UPDRS III at 3 months(%)	71	65	P=0.43
Mean Change in UPDRS III at 2 years (%)	46.5	46.6	P=0.85
Surgical time (Hours)	1.5±0.5	5±1.1	P<0.05
Mean Change in UPDRS at 3 months(%)	71	65	P=0.43
Surgical time (Hours)	1.5±0.5	5±1.1	P<0.05

Out of 50 cases of Pallidotomy group ten cases also had add on Vim thalamotomy who had tremor dependent PD. The tremor and rigidity dependent parkinsons disease had better outcome in both the groups. However, the patients who developed gait related symptoms had the worst outcome.

Our stimulation parameter in most of the cases were high frequency stimulation(130-150 Hz) with 60- 90 us of Pulse width with monopolar or bipolar contacts depending upon the patients' response. Out of 30 cases, two cases had low frequency stimulation with 50 to 60 Hz who developed gait related symptoms.

In long term follow up period after two years, we found that the mean change in off period of UPDRS III score in DBS was 46.6% and in pallidotomy was 46.5%. (p value:0.85). Similarly, the mean change in ADL score after two years waswas 40% in lesioning and 45% in DBS group. (P value 0.9)(table 2) There was only 10 percent reduction on the dose of dopamine in pallidotomy group whereas there was 30 percent reduction in DBS group. Similarly there was significant reduction in Dyskinesia both in Pallidotmy and DBS group.

The complications in pallidotomy group were transient hemiparesis, Dysathria and one parkinsons crisis. The complications in DBS group were were two intracerebral hemorrhage which required immediate evacuation and were fortunately uneventful. One case had wire exposure and two cases had breakage of wire in the cranial end. All three cases required change in the wire.

There were three mortalities in Pallidotomy group in follow up. One mortality was due to Covid infection related complications.There were six mortalities in DBS group in follow up .One case was suicide. Two had aspiration pneumonia and three cases had mortalities due to COVID infection. (Table 3)

Table 3: Result contd:

	Lesioning(Pallidotmy)	DBS
Change in dopaminergic dosage	10% decrease	30% decrease±±
Mean hospital stay	3 ±2 days	About 5±2 days
Complications	One dysarthria,transient hemiparesis and one Parkinsons crisis	Two Intracerebral hemorrhage One wire exposure which requires change in wire 2 wire breakage
Mortality in follow-up	3 (Due to other comorbidities including one due to COVID)	6 including one suicide, 3 due to aspiration pneumonia and 2 due to COVID.
Cost	2 Lakh NRS(1800$)	20 Lakh NRS(18000$)
Follow up number per year	1-2 in a year	4-5 in a year

Discussion

In our analysis, we aimed to evaluate the long-term outcomes of deep brain stimulation (DBS) and lesioning procedures for Parkinson's disease (PD) at a single academic institution. The male-to-female ratio was 2:1 in both cohorts. This result was similar with twice the number of male patients on the literature.[12,13]

No significant difference was observed in the mean duration of illness between the groups. The mean surgical time was significantly shorter in the pallidotomy group, due to avoidance of general anesthesia. The mean surgical duration of DBS was 5 5 hours which was similar to the study by Subin et al.[14]

Likewise, hospital stay was longer in the DBS cohort. On average, patients in the DBS group had four to five follow-up visits per year, whereas the lesioning group required fewer follow-ups which was similar to the study by Bruno et al.[15]
Among the 50 patients in the pallidotomy group, 10 also underwent an adjunctive ventral intermediate nucleus (Vim) thalamotomy owing to tremor-predominant Parkinson's disease.
The mean improvement in the Unified Parkinson's Disease Rating Scale (UPDRS) part III score immediately postoperatively was 70% in the pallidotomy group and 65% in the DBS group. (p=0.4). Initial improvement of motor outcome in terms of UPDRS score III was more in pallidotomy group than in DBS group. In long term follow up, this motor improvement decreased more in pallidotomy group than in DBS group. It was because of the progression of the disease and adjustment of current parameters in DBS group.

In long term follow up period after two years, we found that the mean change in off period of UPDRS III score in DBS was 46.6% and in pallidotomy was 46.5%. (p value:0.85). The mean change in ADL group was 40% in Pallidotomy group and 45% in DBS group.(P=0.9) Many studies have shown improvement in DBS in Off UPDRS score ranging from 31% to 50%.[16-18] .Similarly change in ADL score also ranged from 32% to 50%.[16-20]. Our improvement in motor score of UPDRS in DBS in follow up period was also comparable.[20] A study published by Eisenberg et al have stated the result of MR guided focused ultrasound pallidotomy which showed 45.2% improvement in UPDRS III score in one year follow up. This result is also comparable to our study.[21] Patients with tremor and rigidity dominant subtypes demonstrated more favorable outcomes in both the DBS and lesioning cohorts. Contrary to that, those who developed gait related symptoms experienced the most unfavorable clinical outcome. In a pioneering pilot study, researchers compared three surgical strategies: bilateral subthalamic nucleus deep brain stimulation (STN-DBS), bilateral subthalamotomy, and a hybrid approach combining unilateral subthalamotomy with contralateral STN-DBS implantation.[11] The patient cohort was followed longitudinally for 12 months postoperatively. At the two-year follow-up, all three cohorts exhibited significant improvements in both total and motor Unified Parkinson's Disease Rating Scale (UPDRS) scores, complemented with notable reductions in drug-induced dyskinesias, irrespective of the surgical modality employed.

Hitti et al. demonstrated that, although deep brain stimulation (DBS) does not halt the multifaceted progression of Parkinson's disease, it does provide sustained symptomatic relief of tremor enabling many patients to preserve activities of daily living (ADLs) over a long-term follow-up exceeding a decade.[5] Furthermore, patients' positive reception with DBS remains remarkably high even at a mean follow-up surpassing ten years.

Merello and colleagues assessed outcomes of pallidotomy and stimulator implantation in 13 Parkinson's patients, concluding that while both interventions improved hand-tapping and dyskinesia scores, bilateral improvement in the former was more pronounced following pallidotomy, whereas the latter showed greater enhancement post-stimulator implantation.[22]

Esselink et al. evaluated the effects of unilateral pallidotomy versus bilateral subthalamic nucleus (STN) stimulation in advanced Parkinson's disease patients, observing that the off-phase motor UPDRS scores improved from 46.5 to 37 in the pallidotomy group and from 51.5 to 26.5 in the STN stimulation cohort ($p = 0.002$).[23] These findings align closely with the outcomes reported in our study.

Hariz et al. demonstrated that the long-term impact of posteroventral pallidotomy on dyskinesia is not merely therapeutic but also seemingly prophylactic. Contralateral tremor improved in most patients, although a subset required subsequent surgical interventions for Parkinson's disease. Our findings corroborate with these observations, further affirming the sustained efficacy of this approach.[10]
Hitti et al. reported that tremor associated with Parkinson's disease responds most favorably to deep brain stimulation (DBS), with symptomatic benefits persistent beyond a decade of follow-up.[5] Nevertheless, non-tremor motor manifestations, such as freezing gait and dysarthria seemed to persist despite long-term intervention. Our revelations, derived from a larger patient cohort, corroborate these observations. It is worth a mention that in the pallidotomy subgroup within our series, adjunctive ventral intermediate nucleus (Vim) thalamotomy was mandated for patients with tremor-dominant Parkinson's disease.

Lezcano and colleagues reported sustained tremor improvement at five years postoperatively compared to baseline, although speech and communication functions deteriorated over the same period.[23] A meta-analysis further substantiated that deep brain stimulation (DBS) targeting the subthalamic nucleus (STN) and globus pallidus internus (GPi) provides durable tremor suppression when followed up post operatively up to five years.[24] Likewise, another meta-analysis demonstrated that lesioning procedures and DBS demonstrate parallel efficacy in tremor control.[25] Intriguingly, an exploratory subgroup analyses suggested enhanced quality of life following noninvasive focused ultrasound surgery. Our findings, derived from a larger cohort, bolster these observations.

One study demonstrated that patient's self-reported improvements in activities of daily living (ADLs) were held steady for up to five years following surgery.[23] Conversely, another investigation with a mean follow-up of 11 years documented a cumulative decline in patient's ability to perform ADLs over time.[26] Additionally, a separate cohort study demonstrated that even patients aged 65 years and older treated with subthalamic nucleus deep brain stimulation (STN-DBS)

exhibited notable improvements in ADL performance at three to five years postoperatively. Our outcomes are parallel with these reports, underpinning the durability of functional benefits observed in long-term follow-up.

Our study reveals that patient satisfaction remains comparable between deep brain stimulation (DBS) and lesioning procedures over a long-term follow-up. It merits attention that, in our clinical scenario, pallidotomy has garnered increased recognition over DBS rendering to its lower cost, unwarranted time-intensive battery adjustments, and the elimination of hardware-related complications. Despite the global surge in DBS utilization for Parkinson's disease, neuroablative techniques such as pallidotomies retain a vital role and should not be unjustifiably discarded. Following the FDA's approval of magnetic resonance-guided focused ultrasound (MRgFUS) therapy for Parkinson's Disease in 2018, some centers have reignited their stake in ablative modalities. However the cost of MRgFUS is significant barrier for this procedure in Low and medium income (LMIC) countries like ours. We believe that radiofrequency lesioning offers on-par therapeutic outcomes with better cost-effectiveness profile.

We observed a limited number of surgical complications in our cohort. Those observed in the pallidotomy cohort included transient hemiparesis, dysarthria, and one instance of Parkinsonian crisis. Within the DBS group, two patients experienced intracerebral hemorrhages mandating an urgent surgical evacuation. By a fortunate turn of events, both cases had uneventful recoveries. Moreover, device-related issues were encountered. One presented with lead wire exposure, and two others suffered fractures of the cranial lead wire. These were dealt with surgical revision and wire replacement. The recovery proceeded without any incident. This observation resonates with previously reported complication rates in DBS literature.[27-29]
The mortality during the follow-up period was documented in both cohorts. The pallidotomy group recorded three deaths, one of which was attributable to COVID-19-related complications. The DBS cohort experienced six mortalities, comprising one suicide, two cases of aspiration pneumonia, and three fatalities secondary to COVID-19 infection.

Dopaminergic medication dosage was reduced by approximately 30% in the DBS group, compared to a modest 10% reduction in the pallidotomy group. The average Levodopa Equivalent Daily dose and Levodopa Daily Dose reduction rates were 61.0% and 70.4%, respectively in STN DBS group[30]. There was no significant reduction in dose of dopamine in pallidotomy group.[31] Remarkably, both interventions were associated with a significant decrease in dyskinesia severity.

Conclusion

Both DBS and lesioning are effective for motor symptom relief in PD. DBS remains the gold standard for long-term management, offering adaptability, sustained benefit, and fewer cognitive side effects, especially with GPi stimulation. Lesioning, is a valuable alternative in specific populations: elderly, cognitively impaired, or those without access to long-term DBS care. Emerging evidence suggests that strategic use of lesioning (even multiple targets) can provide durable benefit in select patients. However, DBS continues to offer superior long-term versatility and individualized control. Unilateral or staged bilateral Pallidotomy is safer than bilateral pallidotomy. Pallidotomy has surpassed DBS in our setup as it is cheaper, does not require time consuming adjustment of battery and no hardware related complication

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