

Comparison of Stereotactic Subthalamotomy and Ventralis Intermedius (VIM) Thalamotomy in Relieving Parkinsonian Tremor

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ABSTRACT

Background/Objectives: Parkinson's disease is a neurodegenerative disease with cardinal features of tremor, rigidity, postural instability and bradykinesia. Surgery is indicated for the patients not responding to medical management or who develop motor fluctuations and dyskinesia following prolonged levodopa therapy. Stereotactic Subthalamotomy and VIM (Ventralis Intermedius) Thalamotomy is cheap, safe and effective surgical options for the treatment of Parkinsonian tremor. The objective of the study was to compare Stereotactic Subthalamotomy with Ventralis Intermedius (VIM) Thalamotomy, in terms of improvement in Unified Parkinson's Disease Rating Scale (UPDRS), for the treatment of Parkinsonian tremor.

Material and Methods: This is a randomized control trial (RCT) and 38 tremor predominant Parkinsonian patients were enrolled in the study. Half of the patients underwent Stereotactic Subthalamotomy and another half underwent VIM Thalamotomy. Patients were assessed pre-operatively, immediately post-operatively and followed up at three weeks, six weeks and three months by using UPDRS scores.

Results: The mean age of patients was 59.58 years and they were predominantly male. Post-operative UPDRS score was improved significantly in both STN and VIM groups. However, the improvement was significantly higher in STN lesioning compared to VIM lesioning. On the other hand, the improvement in tremor component score of UPDRS was comparable in the both groups. Moreover, post-operative complications were higher following Subthalamotomy (21.05%) which included dyskinesia, dysphasia, transient weakness and hematoma formation.

Conclusion: Both Stereotactic Subthalamotomy and VIM Thalamotomy are equally effective in relieving Parkinsonian tremor with a lower complication rate following VIM Thalamotomy.

Keywords: Parkinson's disease, Subthalamotomy, VIM Thalamotomy, Unified Parkinson's disease Rating Score.

Abbreviations: VIM: Ventralis Intermedius. RCT: Randomized Control Trial. PD: Parkinson's disease. UPDRS: Unified Parkinson's disease Rating Scale. DBS: Deep Brain Stimulation. STN: Subthalamic Nucleus.

INTRODUCTION

The study was aimed to compare the Stereotactic Subthalamotomy with Ventralis Intermedius (VIM) Thalamotomy, in terms of improvement in Unified Parkinson's Disease Rating Scale (UPDRS), for the treatment of Parkinsonian tremor.

Parkinson's disease (PD) is a progressive

neurodegenerative disease with an incidence of 4.5 to 21 per 100,000 populations per year, which is only second to Alzheimer's disease.¹ The average age of onset is 60 years with male predominance.² Two major neuropathological findings in this disease are loss of pigmented dopaminergic neurons in **substantia nigra** and the presence of Lewy bodies and **Lewy neuritis**.^{3,4}

Clinical diagnosis is made on the basis of four characteristic features: resting tremor, rigidity, postural instability and bradykinesia.⁵

Levodopa along with **carbidopa**, remains the standard medical treatment of motor symptoms of the disease. However, some patients present with motor fluctuations and dyskinesia with its long term use.⁶ Thus, surgical treatment is reserved for patients with either decrease response to medical treatment or development of drug related complications.

Deep Brain Stimulation (DBS) of VIM (Ventralis Intermedius) nucleus or STN (Subthalamic nucleus) is a surgery of choice for Parkinsonian tremor but it is an expensive procedure. Alternate cheap, safe and effective surgical options are Stereotactic Subthalamotomy and VIM Thalamotomy. Today, the provision of magnetic resonance based images along with the development of **SurgiPlan workstation** with **inbuilt digital brain atlas**; the localization of target has become more precise. Furthermore, safe trajectory to the target can be defined avoiding sulci, ventricles and internal capsule reducing surgical morbidity. Final level of accuracy lies in **functional mapping** using pre-operative **macro-electrode stimulation** in awake before making permanent lesion using **radiofrequency lesion generator**.⁷

MATERIAL AND METHODS

Study Design and Setting

It was the randomized control trial (RCT) conducted in the Department of Neurosurgery (Unit-II), Lahore General Hospital (LGH), Lahore, Pakistan from March 2015 to February 2017 after clearance from the ethical committee. Non probability, purposive sampling technique was used. Thirty eight patients were enrolled in the study. Allocation of a particular procedure was done by random method. Half of the patients were operated via. Subthalamotomy and the other half were operated via. VIM Thalamotomy. Informed consents were taken from all patients fulfilling the inclusion criteria after explaining details of the procedure, outcome, and risks.

Inclusion Criteria

Patients included in the study were medically refractory Parkinsonian patients getting maximum doses of carbidopa (200 mg/day) and Levodopa (800 mg/day) for at least 6 months and those who developed drug induced dyskinesia.

Exclusion Criteria

Patients with tremors due to stroke/infarction, head injury or demyelination; lesions in basal ganglia; those having malignant diseases, bleeding diathesis and cognitive decline were excluded from the study.

Data Collection and Clinical Management

Detail history and neurological assessment of enrolled patients were carried out and preoperative UPDRS was recorded. Pre-operatively MRI brain (non-contrast) was done in all patients to rule out any structural abnormality. All the Parkinsonian drugs were stopped one day before surgery.

Procedure

After application of stereotactic Leksell G frame under local anesthesia, MRI Brain with contrast was done and the image was transferred to **SurgiPlan workstation**. Then the target was calculated for Subthalamic nucleus (STN) and VIM nucleus using **Laitinen formula**. This acquired target on MRI was confirmed by superimposing on **Shelton Bran digital brain atlas**. Once the desired target was confirmed, the trajectory was determined with SurgiPlan avoiding sulci, ventricles, internal capsule and blood vessels.

The Leksell frame was fixed to the OT table adjusting X, Y, Z, arc and rings according to the calculations. A 14mm burr hole was made under local anesthesia. A stereotactic 2.1mm microelectrode was then inserted while the frame was adjusted in such a way that tips of electrode were -4mm above the target (zero). The electrode was connected through leads to the Cosman lesion generator with stimulation parameters set at a frequency of 130 Hz, voltage of 1.5 Volts and pulse width of 0.2 milliseconds. The electrode was gradually advanced at 2mm interval till patient's symptoms disappeared. During stimulation patients were evaluated for the disappearance of tremors and side effects of stimulation like contralateral tetanic contractions of arms and legs, contralateral deviation of eyes, any paresthesias or visual hallucinations. Once the target was physiologically confirmed, a permanent lesion was made by setting temperature at 50°C for one minute, then on 70°C and finally on 90°C for one minute.

Post-Operative Management

Post-operatively, the patients were shifted to the recovery room and CT scan was obtained after 8 hours, to see any hematoma. The pre-op medications for Parkinsonism were restarted. Patients were evaluated in the next morning and UPDRS score along with any complications were recorded. An MRI scan with 2mm cuts of T1W and T2W images was obtained to confirm the placement of lesion. Patients were then discharged on medications with doses readjusted in consultation with neurologist. Follow up was done with UPDRS score at 3 weeks, 6 weeks and 3 months.

Data Analysis

Statistical analysis was done using **Statistical Package for Social Sciences (SPSS)** version 22. The qualitative data like demographics were documented as percentage and frequency distribution tables and compared using chi-square test. The **quantitative data** like age were presented in Mean \pm Standard Deviation.

After fulfilling the parametric test assumptions, **paired sample t-test** was used to compare differences before and after treatment in the UPDRS score and **independent sample student's t-test** was applied to determine the **significant differences** between the UPDRS score of both groups. The p value of ≤ 0.05 was considered as **significant**.

RESULTS

Thirty eight patients were

Table 1: Distribution of Patient by Age in Both Study Groups.

	Study Groups	Mean	Standard Deviation (S.D)	Minimum	Maximum	P value
Age (years)	STN (n = 19)	61.00	5.48	50	70	0.118
	VIM (n = 19)	58.16	5.44	45	67	
	Total (n = 38)	59.58	5.58	45	70	

Table 2: Comparison of Presenting Complaints in Both Study Groups.

Presenting Complaints	Study Groups	
	STN Group	VIM Group
Bilateral tremor with mild rigidity and bradykinesia	7 (36.84%)	6 (31.58%)
Predominant right sided tremor with mild rigidity \pm bradykinesia	5 (26.31%)	7 (36.84%)
Predominant left sided tremor with mild rigidity \pm bradykinesia	4 (21.05%)	4 (21.05%)
Unilateral tremor with bradykinesia	3 (15.78%)	2 (10.53%)
Total	19	19

Table 3: Comparison of Duration of Disease and Treatment in Both Study Groups.

	Study Groups	Mean	S.D	Minimum	Maximum	P value
Duration of Disease (Years)	STN (n = 19)	9.16	3.55	3.00	15.00	0.824
	VIM (n = 19)	8.89	3.70	3.00	15.00	
	Total (n = 38)	9.03	3.58	3.00	15.00	
Duration of Treatment (Years)	STN (n = 19)	7.26	3.87	2.00	15.00	0.970
	VIM (n = 19)	7.32	4.62	2.00	15.00	
	Total (n = 38)	7.29	4.20	2.00	15.00	

Table 4: Comparison between Pre-operative and Post-operative UPDRS Score in Subthalamotomy (STN) Group.

	Mean	SD	t-test (p value)
Pre-operative	19.32	1.797	
Paired Comparison			
Pre-operative vs. Immediate post-operative	7.95	1.224	33.92 (< 0.0001)
Pre-operative vs. 3 weeks follow-up	7.89	0.994	40.92 (< 0.0001)
Pre-operative vs. 6 weeks follow up	7.53	1.124	43.46 (< 0.0001)
Pre-operative vs. 3 months follow-up	7.47	1.073	41.00 (< 0.0001)
Immediate post-operative vs. 3 months post-operative	7.95 7.47	1.224 1.073	2.96 (0.008)

Table 5: Comparison between Pre-operative and Post-operative UPDRS Scores in VIM Thalamotomy Group.

	Mean	SD	t-test (p value)
Pre-operative	18.58	1.610	
Paired Comparison			
Pre-operative vs. Immediate post-operative	9.0	1.106	46.311 (< 0.0001)
Pre-operative vs. 3 weeks follow-up	8.84	1.214	45.47 (< 0.0001)
Pre-operative vs. 6 weeks follow up	8.63	1.116	47.58 (< 0.0001)
Pre-operative vs. 3 months follow-up	8.53	1.264	34.55 (< 0.0001)
Immediate post-operative vs. 3 months post-operative	9.0 8.53	1.106 1.264	2.964 (0.008)

included in our study, 19 each in VIM Thalamotomy and Subthalamotomy (STN) group.

Gender Distribution:

There were 14 (73.68%) male and 5 (26.32%) females in the STN group while 17 (89.47%) male and 2 (10.53%) females in VIM group, p-value > 0.05.

Distribution of Patient by Age:

Overall mean age of the patients was 59.58 ± 5.44 years. The mean age in VIM and STN group was 61 ± 5.48 and 58.16 ± 5.44 years, respectively (Table 1).

Distribution of Patients According to Presenting Complaints:

Majority of the patients presented with bilateral symptoms (tremor, rigidity and bradykinesia) in both the groups followed by predominantly right sided tremor, rigidity and bradykinesia. Presentation with only unilateral tremor was least common in both VIM Thalamotomy and Subthalamotomy groups (Table 2).

Duration of Disease and Treatment:

The mean duration of disease in STN group and VIM group was 9.16 ± 3.55 years and 8.89 ± 3.70 years respectively whereas, the mean duration of treatment in STN group was 7.26 ± 3.87 years and VIM group was 7.32 ± 4.62 years, with no statistical difference

between means (Table 3).

Comparison between Pre-operative and Post-operative UPDRS Scores in Subthalamotomy Group:

The mean UPDRS score was significantly reduced in immediate post-operative period when compared to pre-operative score and the improvement was persistently sustained throughout the 3 weeks, 6 weeks and 3 months follow-up. Similarly, after 3 months of procedure the mean UPDRS score was improved significantly when compared to post-operative score with $p < 0.05$ (Table 4).

Comparison between Pre-operative and Post-operative UPDRS Scores in VIM Thalamotomy Group:

The mean UPDRS score was significantly reduced in immediate post-operative period when compared to pre-operative score and the improvement was persistently sustained throughout the 3 weeks, 6 weeks and 3 months follow-up. Similarly, after 3 months of procedure the mean UPDRS score was improved significantly when compared to post-operative score with $p < 0.05$ (Table 5).

Comparison of UPDRS Scores between Subthalamotomy (STN) and VIM Thalamotomy Groups:

The difference in mean pre-operative UPDRS score between STN (19.32 ± 1.80) and VIM (18.58 ± 1.6) was not statistically significant ($p = 0.191$). After surgery, it was observed as 7.95 ± 1.22 in STN group and 9.0 ± 1.11 in VIM group. This shows statistically significant improvement in UPDRS score following Subthalamotomy compared to VIM Thalamotomy. It was observed that improvement in terms of UPDRS score was significantly more and sustained throughout 3 weeks, 6 weeks and 3 months follow-up in STN group as compared to VIM Thalamotomy group with $p < 0.05$ (Table 6).

Comparison of Mean Tremor Component score of UPDRS Before and After Surgery in Subthalamotomy (STN) Group:

The mean pre-operative tremor component score of UPDRS score was significantly reduced after

Table 6: Comparison of UPDRS Score in Both Study Groups.

UPDRS Score	Study Groups	Mean	S.D	Minimum	Maximum	t-test (p value)
Pre-operative	STN (n = 19)	19.32	1.80	17	23	1.33 (0.191)
	VIM (n = 19)	18.58	1.61	16	22	
	Total (n = 38)	18.95	1.72	16	23	
Post-operative	STN (n = 19)	7.95	1.22	6	10	-2.78 (0.009)
	VIM (n = 19)	9.00	1.11	7	11	
3 weeks	STN (n = 19)	7.89	0.99	6	10	-2.63 (0.012)
	VIM (n = 19)	8.84	1.21	7	11	
6 weeks	STN (n = 19)	7.53	1.12	6	10	-3.04 (0.004)
	VIM (n = 19)	8.63	1.12	7	11	
3 months	STN (n = 19)	7.47	1.07	6	9	-2.76 (0.009)
	VIM (n = 19)	8.53	1.26	7	11	

and 3 months with $p < 0.05$. Similarly, while comparing immediate post-operative score with 3 months follow up score, the improvement was statistically significant (table 7).

Comparison of Mean Tremor Component Score of UPDRS before and After Surgery in VIM Thalamotomy Group:

The mean pre-operative tremor component score of UPDRS score was significantly reduced after surgery and during subsequent follow up at 3 weeks, 6 weeks and 3 months with $p < 0.05$. Similarly, while comparing immediate post-operative score with 3 months follow up score, the improvement was statistically significant (table 8).

Comparison of Tremor Component Score of UPDRS between Two Study Groups:

The mean pre-operative tremor component of UPDRS score was 2.63 ± 0.49 and 2.57 ± 0.50 in STN and VIM group respectively, the difference was not statistically significant ($p = 0.748$). The mean tremor component was 0.78 ± 0.71 in

Table 7: Comparison of Mean Tremor Component Score of UPDRS before and After Surgery in Subthalamotomy (STN) Group.

	Tremor component of UPDRS score (Mean)	SD	t-test (p value)
Pre-operative	2.63	0.50	
Paired Comparison			
Pre-operative vs. Immediate post-operative	0.79	0.71	8.93 (< 0.001)
Pre-operative vs. 3 weeks follow-up	0.68	0.67	10.01 (< 0.001)
Pre-operative vs. 6 weeks follow up	0.53	0.51	12.44 (< 0.001)
Pre-operative vs. 3 months follow-up	0.53	0.51	12.44 (< 0.001)
Immediate post-operative vs. 3 months post-operative	0.79 0.53	0.71 0.51	2.53 (0.021)

Table 8: Comparison of Mean Tremor Component Score of UPDRS before and After Surgery in VIM Thalamotomy Group.

	Tremor component of UPDRS score (Mean)	SD	t-test (p value)
Pre-operative	2.58	0.51	
Paired Comparison			
Pre-operative vs. Immediate post-operative	0.74	0.65	10.50 (< 0.001)
Pre-operative vs. 3 weeks follow-up	0.74	0.45	11.67 (< 0.001)
Pre-operative vs. 6 weeks follow up	0.58	0.51	11.69 (< 0.001)
Pre-operative vs. 3 months follow-up	0.58	0.51	11.69 (< 0.001)
Immediate post-operative vs. 3 months post-operative	0.74 0.58	0.65 0.51	1.83 (0.083)

STN group and $0.73 \pm 0.0.65$ in VIM group during immediate post-operative period which was not significantly different. Similarly, difference in improvement in tremor scores between two groups during subsequent follow up at 3 weeks, 6 weeks and 3 months was also comparable statistically (Table 9).

Table 9: Comparison of Tremor Component of UPDRS Score in Both Study Groups.

Tremor Component of UPDRS Score	Procedure	Mean	S.D	P value
Pre-operative	STN (n = 19)	2.63	0.49	0.748
	VIM (n = 19)	2.57	0.50	
Immediate post-operative	STN (n = 19)	0.78	0.71	0.814
	VIM (n = 19)	0.73	0.65	
3 weeks follow-up	STN (n = 19)	0.68	0.67	0.778
	VIM (n = 19)	0.73	0.45	
6 weeks follow up	STN (n = 19)	0.52	0.51	0.752
	VIM (n = 19)	0.57	0.50	
3 months follow up	STN (n = 19)	0.52	0.52	0.753
	VIM (n = 19)	0.57	0.50	

Post-operative Complications

Overall, 10.52% and 21.05% complications occurred in VIM and STN groups, respectively ($p < 0.05$). One patient in VIM group had surgical site infection that was treated with antibiotics. One patient in each group had transient weakness that improved within few weeks. Similarly, three more complications were encountered in STN group (dyskinesia, dysphasia and small intraparenchymal hematoma). Dyskinesia in contralateral upper limb was managed with readjustment of anti-Parkinsonian medications and disappeared completely at the end of 3 months. Similarly, expressive dysphasia was seen in one patient who showed gradual improvement during subsequent follow-up. Small intraparenchymal hematoma (volume < 10 ml) in one patient was managed conservatively (Table 10).

Table 10: Comparison of Complications in Both Study Groups.

Complications	Study Groups	
	VIM	STN
Wound infection	1 (5.26%)	0 (0%)
Transient weakness	1 (5.26%)	1 (5.26%)
Dyskinesia	0 (0%)	1 (5.26%)
Dysphasia	0 (0%)	1 (5.26%)
Small hematoma	0 (0%)	1 (5.26%)

DISCUSSION

Parkinson's disease is a progressive neurodegenerative disease affecting middle age to elderly population. Onset of the disease is after sixth decade of life and less than 4% of the Parkinsonian patients are below 50 years of age.⁸ The mean age of presentation in our study is 59.58 years with range of 45 – 70 years. Progression of the disease with age is attributed to progressive degeneration of dopaminergic neurons in substantia nigra.⁹ The disease is more common in men than women (gender ratio: 1.5:1–2:1).^{2,8} The male to female ratio in our study was 4.4:1. This ratio is high compared to other international studies owing to differences in the referral pattern.

Patients with Parkinson's disease develop motor symptoms gradually over the years with progressive degeneration of dopaminergic neurons. Clinical manifestations appear when more than 50% dopaminergic neuronal loss has occurred. The mean duration of disease before seeking surgical intervention in our study was 9.03 years with varying range of 3 to 15 years. Similar results were seen in patients undergoing VIM Thalamotomy in Fraix et al. study (mean age of 8 years and range of 1-19 years) and patients undergoing Subthalamotomy in Alvarez et al study (mean age of 10.8 years and range of 5 – 27 years).^{10,11}

Patients receive anti-Parkinsonian medications for a variable period of time before they develop motor fluctuations and dyskinesia with escalating doses. In our study, the mean duration of medical treatment before surgical intervention was 7.29 years with range of 2 to 15 years. Olanow et al. estimated that as many as 50% of Parkinsonian patients on levodopa for five years develop motor fluctuations and dyskinesia.¹² Motor complications are more frequent in younger onset of the disease. In our study four patients presented with dyskinesia.

Both, Stereotactic VIM Thalamotomy and Subthalamotomy were associated with significant improvement in post-operative UPDRS scores. In a study conducted by Sobstyl et al., among 41 tremor predominant PD patients who underwent VIM Thalamotomy, the mean preoperative UPDRS of 11.2 improved to 2.6⁷. Similar results were seen in Boecker et al. study following VIM Thalamotomy in tremor dominant Parkinsonian patients¹³. Following Subthalamotomy by Tarsy et al. in 89 Parkinsonian patients, UPDRS scores while off medication improved by 50% at 12 months.¹⁴ A study by Patel et al. in 2003, showed that Stereotactic lesioning of STN in 21 Parkinsonian patients had significant improvement in rigidity, contralateral tremor and bradykinesia with maximum effect on tremor component. There was a significant improvement in the UPDRS scores on medication and off medication at 6, 12 and 24 months follow up¹⁵. In another study by Su et al. in 2002, STN lesioning in 12 patients with 12 months follow up showed improvement in UPDRS scores by 30% in off period, 38% in on period.¹⁶

In our study, improvement in mean post-operative UPDRS score was significantly higher in Subthalamotomy group compared to VIM Thalamotomy group. This difference in two groups was persistent throughout 3 weeks, 6 weeks and 3 months follow-up. This significant difference in two groups may be attributed to the fact that STN lesioning is associated with post-operative improvement in not only the tremor component but also rigidity, bradykinesia and postural instability.¹⁶ On the other hand VIM lesioning has no or minimal effect on rigidity, bradykinesia and rigidity.¹⁷

We also studied the tremor component of UPDRS score separately. The mean pre-operative tremor component score in STN group was 2.63. Nine patients (47.36%) had complete cessation of tremor at 3 months follow up while ten patients had significant improvement with mean score of 0.53 at latest follow-up. Similarly, mean pre-operative tremor score in VIM group was 2.58. Eight patients (42.1%) had complete cessation of tremor at 3 months follow-up while 11 patients had significant improvement with mean score of 0.58 at latest follow-up. Jankovic et al. in 1995 conducted a retrospective study among 42 patients who underwent Stereotactic VIM Thalamotomy for Parkinsonian tremor. During follow up 86% of patients had complete cessation or significant improvement in contralateral tremor.¹⁸ Similar results were shown by Balás et al. in 2001, where he

conducted Thalamotomy in 34 tremor predominant Parkinsonian patients with 12 months average follow-up. The result showed 88% of patients with complete cessation or marked improvement in contralateral tremor.¹⁹ Alvarez et al. in 2009 studied the role of Subthalamotomy in 68 Parkinsonian patients which showed tremor score of 2.2 pre-operatively improved to 0.2 at 12 months follow-up.¹¹

There was no significant difference in terms of improvement in tremor scores between two groups. No study is available in literature review comparing STN and VIM lesioning. However, Parihar et al. in 2015 compared the results of VIM and STN stimulation (DBS) in Parkinsonian tremor. The degree of improvement in postural or action tremor scores between VIM DBS and STN DBS was not significantly different. Postural/action tremor improved 72% in the VIM DBS group and 68% in the STN group.²⁰

Post-operative complications were higher in stereotactic STN lesioning (21.05%) compared to VIM lesioning (10.52%). There was no mortality or cognitive impairment in both groups. Our results were comparable with other international studies. Jankovic et al. encountered immediate postoperative complications in 58% of patients following VIM lesioning with most common being contralateral weakness (34%) followed by dysarthria (29%) and confusion (23%). But these complications rapidly resolved during post-operative period¹⁸. Similarly, in a study conducted by Sobstyl et al. in 41 tremor predominant Parkinsonian patients who underwent stereotactic VIM Thalamotomy, 13 patients had transient and 6 had permanent complications⁷. In a case series of 89 Subthalamotomy conducted by Alvarez et al., 52 patients developed contralateral dyskinesia that resolved gradually in 38 cases. However, 14 patients had hemiballism and chorea which required Pallidotomy¹¹. Relatively higher incidence of complications in STN group may be due to a small target of Subthalamic nucleus. Thus, macroelectrode monitoring helps proper localization of the target and prevents possible complications.

Recently, MR-guided high intensity focused ultrasound lesioning of VIM and Subthalamic nucleus has been considered safe and effective in treatment of Parkinsonian patients with lower complications rate like dysphagia and dysarthria²¹. Similarly, using modern functional Stereotactic Radiosurgery (SRS) parameters, radiosurgery Thalamotomy has become a safe and useful procedure for patients who are not

suitable for an open surgical procedure. The reported results and complications of SRS are comparable to those of thalamic lesions generated by radiofrequency procedures. However, further studies are necessary to establish the role of SRS targeting the STN, since its small size and complex anatomical relationships make this nucleus less suitable for the procedure.²²

CONCLUSION

Both Stereotactic VIM Thalamotomy and Subthalamotomy are equally effective in relieving tremor in tremor predominant Parkinsonism. However, overall improvement in total UPDRS score is significantly higher following STN lesioning compared to VIM lesioning. And this improvement comes at a cost of higher complication rate compared to VIM Thalamotomy.

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In compliance with the ICMJE uniform disclosure form, all authors declare the following:

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1.	Somraj Lamichhane	Study design and methodology.
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