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# Subthalamotomy versus Pallidotomy for Parkinsonian Rigidity: A Quasi-Experimental Study in a Resource Limited Tertiary Center

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## Abstract

**Objective:** To compare motor outcomes and postoperative complications of subthalamotomy versus pallidotomy for Parkinsonian rigidity in a resource-limited setting where deep-brain stimulation is not affordable.

**Methodology:** This quasi-experimental study was carried out at the Department of Neurosurgery, Punjab Institute of Neurosciences, Lahore, from 2016 to 2021. Forty patients with Parkinson's disease were included. Twenty patients underwent pallidotomy, in which a small, precisely targeted lesion was made in the globus pallidus region of the brain, and twenty had a subthalamotomy, involving a lesion in the subthalamic nucleus. Each patient's motor function was assessed before surgery and at regular follow-ups using the Unified Parkinson's Disease Rating Scale (UPDRS) part III, a standard measure of movement difficulty in Parkinson's disease. Postoperative complications were also recorded. The changes in UPDRS scores and complications were compared within and between groups.

**Results:** The mean age was 47.6 ± 8.7 years, and 85% of patients were male. Both procedures produced significant postoperative improvement in motor scores ($p < 0.001$). In the pallidotomy group, the UPDRS Part III score improved from 24.9 ± 1.47 to 10.47 ± 0.86 (42% improvement), and in the subthalamotomy group from 25.48 ± 1.55 to 10.26 ± 1.18 (40.2% improvement). Although pallidotomy showed a slightly greater numerical reduction in UPDRS scores, the difference between groups was not statistically significant ($p > 0.05$). Complications were less frequent after pallidotomy (10%) compared with subthalamotomy (35%), but this difference was not statistically significant.

**Conclusion:** Both procedures are effective in treating Parkinsonian rigidity. No statistically significant difference was observed between the two procedures in terms of relief of symptoms. Fewer complications were associated with pallidotomies as compared with subthalamotomies.

**Keywords:** Parkinson's disease, Pallidotomy, Subthalamotomy, STN lesioning, Unified Parkinson's Disease Rating Scale

## Introduction

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder named after James Parkinson, and is the second most common neurodegenerative disease worldwide after Alzheimer's disease. It is an incurable, debilitating condition affecting approximately 11.7 million people globally.[1,2] The classical motor manifestations include resting tremor, bradykinesia, muscular rigidity, and postural instability, with a male predominance of about 1.5:1 compared to females.[3,4] Clinically overt motor symptoms typically emerge after the substantia nigra has lost more than about 50% of dopaminergic neurons. Although no medical or surgical treatment can halt or reverse the disease process, symptom progression can be mitigated with antiparkinsonian drugs such as levodopa, anticholinergics, dopamine agonists, and catechol-O-methyltransferase inhibitors, used alone or in combination. However, long-term pharmacotherapy is frequently complicated by motor fluctuations and dyskinesias, prompting consideration of surgical options in advanced cases.

Surgical interventions are generally reserved for patients with severe, medically refractory symptoms. Contemporary neurosurgical strategies include deep brain stimulation (DBS), medication infusion systems, and ablative (lesioning) procedures targeting specific basal ganglia structures.[5] DBS has become the preferred surgical approach for advanced PD in many centers because it is adjustable, reversible, and associated with a favorable safety profile. Nevertheless, the high cost of hardware, need for device maintenance, and long-term follow-up substantially limit its accessibility in low- and middle-income countries.[6] In such resource-constrained settings, lesioning procedures remain an important, pragmatic alternative for carefully selected patients.[7]

Among ablative procedures, pallidotomy targets the internal segment of the globus pallidus (GPi), whereas subthalamotomy targets the subthalamic nucleus (STN). The STN is a relatively newer lesioning target compared with the GPi; its use was initially supported by encouraging results in primate models of PD,[8] although early

concerns about inducing hemiballismus delayed broader application in humans. Subsequent clinical experience has shown that STN lesioning can improve all cardinal motor features of PD and reduce levodopa requirements by approximately 42%, thereby potentially decreasing the drug-induced complications; significant motor gains are typically observed within 6–8 months,[9] with reports of around 50% improvement in rigidity and other motor symptoms. Clinical series by McCarter and Alvarez reported no major adverse effects on cognition, balance, or swallowing,[10] although other studies have documented procedure-related complications such as dyskinesias, speech disturbances, and ataxia.[11] These data support lesioning of the STN as a viable, cost-conscious option in appropriately selected patients when DBS is not feasible. Despite International reports describing the effectiveness of subthalamotomy and pallidotomy, direct comparative evidence between the two procedures remains limited, especially in low-resource health systems where DBS is not financially accessible. Most available studies are small, single-arm case series conducted in high-income countries, and there is little published data on surgical outcomes, complication rates, and short-term functional improvement in South Asian populations.

Because lesioning procedures remain a practical alternative in Pakistan due to cost constraints, there is a critical need for locally generated comparative data to guide decision-making. This study addresses this gap by directly comparing motor improvement and postoperative complications between stereotactic subthalamotomy and pallidotomy in patients with Parkinsonian rigidity in the local population.

## Methodology

This prospective quasi-experimental study was carried out at Neurosurgery unit II of Punjab Institute of Neurosciences, Lahore General Hospital, for five years, from 2016 to 2021, after approval from the Ethical Review Board (LGH/00/156/16). Given the low annual procedural volume for these lesioning techniques and the need for standardized postoperative follow-up, the study was designed as a multi-year prospective cohort. Ethical approval covered the entire recruitment and follow-up period. Forty participants were recruited in the study. Allocation into groups was done through non-probability convenience sampling by a consultant neurosurgeon, without any specific criteria, as it was difficult to dichotomize the patients due to their diverse clinical presentations. Allocation was based on surgeon judgment, as rigid randomization was not feasible due to heterogeneity of clinical presentations. Twenty participants each were assigned to the pallidotomy and subthalamotomy groups.

Those patients with Parkinsonian rigidity were included in the study who had initially shown a good response to antiparkinsonian medication but later experienced either a diminished therapeutic effect or the development of treatment-related complications, of either gender, between 30 and 70 years of age. Patients with a history of stroke, intracranial tumour, or prior surgery for head trauma were excluded, as were those with malignant diseases or evidence of cognitive decline. Individuals with any form of bleeding diathesis were also not considered eligible for inclusion in the study.

The following variables were recorded for each patient: age, categorized as <40 years, 40–60 years, or >60 years; gender; and presenting symptoms, which included rigidity (unilateral or bilateral, with left predominance, right predominance, or symmetrical involvement), bradykinesia, gait disturbances or ataxia, micrographia, and tremors (left- or right-predominant). Motor severity was assessed using Part III of the UPDRS, which focuses on the motor examination. although UPDRS comprises four parts, only Part III (motor examination) was used in this study, and all reported UPDRS scores refer exclusively to this section. UPDRS Part III consists of 18 items, each scored from 0 (normal) to 4 (severe disability), yielding a maximum total score of 72. UPDRS scoring before and after the intervention was calculated, assessed, and analyzed by a consultant neurosurgeon who was not involved in the study and was therefore blinded.

Postoperative complications were also documented and included vascular complications (hematoma, stroke, or infarction), wound-related complications (infection, cerebrospinal fluid fistula), motor complications (motor weakness, dyskinesias, swallowing difficulties, and dysphasias), and cognitive complications (cognitive decline and memory deficits). In addition, any mortality occurring within the 3-month postoperative follow-up period was recorded.

Patients fulfilling the inclusion criteria were enrolled from the outpatient department. Informed consent was taken from the patient after they were informed of the details of the procedure, its outcome, and associated risks. The assessor was blinded to the procedure. Patients fulfilling the inclusion criteria were admitted through OPD, and UPDRS was noted. The motor component of UPDRS was considered in the study. After taking informed consent from the patients, they were subjected to surgery under local anaesthesia. Any drugs the patient was taking for PD were discontinued. The procedures were guided by metal frames placed on the patients' heads. Four pins, two in front and two at the back, were applied to fix the frame. Once a square was ensured, the fiducial box was applied. The box fitted snugly only if the frame was square. The MRI was used to locate the STN and GPi, which were the exact brain targets responsible for Parkinsonian movement difficulties.

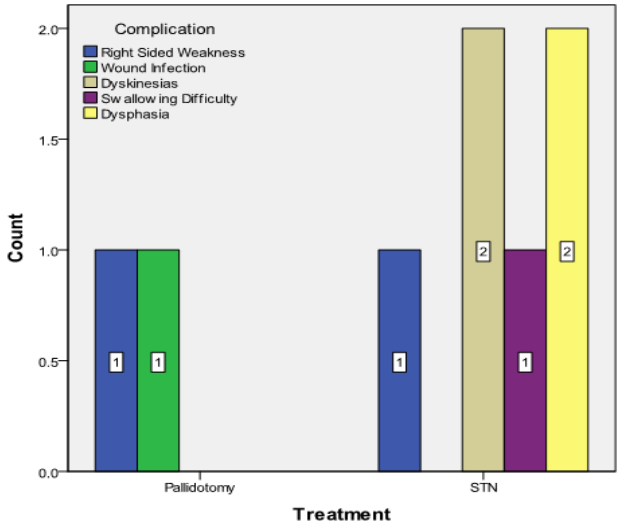
Both procedures were performed under local anesthesia using MRI guidance to accurately locate the target areas in the brain. A small electrode was inserted through a tiny opening in the skull, and controlled heat was applied to create a lesion in the region responsible for Parkinsonian rigidity.After the procedure, patients were observed in the recovery room for an hour and then transferred to the ward. A postoperative CT scan was performed 8–12 hours later to check for any bleeding or other complications, and antiparkinsonian medications that had been paused were restarted. The following morning, patients were evaluated, and UPDRS scores and complications were documented. A postoperative MRI was also obtained to confirm lesion placement. Patients were then discharged with instructions to continue their medications and attend follow-up visits. At the 3-month follow-up, UPDRS scores were recorded again and any complications noted during hospitalization or the follow-up period were documented.

Data were analyzed using IBM SPSS Statistics version 27. Continuous variables (age and UPDRS Part III scores) were summarized as mean ± standard deviation, while categorical variables (sex and postoperative complications) were presented as frequencies and percentages. Normality of continuous variables was assessed (assuming approximate normal distribution for UPDRS scores). Within-group comparisons of preoperative and 3-month postoperative UPDRS Part III scores were performed using paired t-tests. Between-group comparisons of 3-month postoperative UPDRS Part III scores (pallidotomy vs. subthalamotomy) were performed using independent samples t-tests. Associations between categorical variables, including postoperative complication rates, were evaluated using chi-square tests. A p-value ≤0.05 was considered statistically significant.

## Results

In this study, the mean age of the patients was 47.58±8.69 years. 11 (27.5%) patients were younger than 40 years of age, 14 (35%) were between 40 and 50 years of age, and 15 (37.5%) were older than 60 years. 34 (85%) patients were male, and 6 (15%) were female. In the pallidotomy group, 14 (70%) were male and 6 (30%) were female, whereas in the STN group, all (100%) were male. Mean baseline UPDRS Part III scores were 24.90 ± 1.47 in the pallidotomy group and 25.48 ± 1.55 in the subthalamotomy group, with no statistically significant difference between groups. However, sex distribution differed between groups, with all patients in the subthalamotomy group being male.

In the pallidotomy group (n = 20), the most frequent presenting pattern was bilateral rigidity with bradykinesia in 5 patients (25.0%), followed by bilateral rigidity with bradykinesia and ataxia in 4 patients (20.0%), bilateral rigidity was more marked on the right side in 4 patients (20.0%), and bilateral rigidity was more marked on the left side in 3 patients (15.0%); in addition, 4 patients (20.0%) presented with difficulty in walking, Micrographia, bradykinesia, and bilateral rigidity. In the STN group (n = 20), right-sided tremors with predominant right-sided rigidity and bradykinesia were observed in 6 patients (30.0%), left-sided tremors with predominant left-sided rigidity and bradykinesia in 5 patients (25.0%), while 9 patients (45.0%) had predominantly bilateral rigidity. UPDRS part III scores were recorded for both pallidotomy and subthalamotomy groups. The patients scored the following:




**Graph 1:** Comparison of postoperative complications between pallidotomy and subthalamotomy at 3 months

**Table 1:** Mean and standard deviation of preoperative and 3-month postoperative UPDRS Part III total motor scores (pallidotomy group)

| | Mean | Std. Deviation |
|---|---|---|
| pre-op UPDRS | 24.90 | 1.470 |
| 3 months | 10.47 | .860 |

There was a 42% improvement in mean UPDRS score postoperatively. The difference between preoperative and 3-month post-operative UPDRS was statistically significant (p <0.001) in the pallidotomy group.

**Table 2:** Mean and standard deviation of preoperative and 3-month postoperative UPDRS Part III total motor scores (subthalamotomy group

| Treatment | Mean | Std. Deviation |
|---|---|---|
| pre-op UPDRS | 25.48 | 1.546 |
| 3 months | 10.26 | 1.182 |

There was a 40.2% improvement in mean UPDRS score postoperatively. The difference between preoperative and 3-month post-operative UPDRS was statistically significant (p <0.001) in the subthalamotomy group.

**Table 3:** Comparison of Stereotactic Subthalamotomy and Pallidotomy UPDRS Part III total motor scores

| | Treatment | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| 3 months | Pallidotomy | 10.47 | 0.86 | 0.157 |
| | STN | 10.26 | 1.18 | 0.212 |

The difference between Stereotactic Subthalamotomy and Pallidotomy in terms of UPDRS at 3 months post op was statistically insignificant (p-value=0.435)

Postoperative complications were found to be few and far between, with none of the patients developing any vascular complications (hematoma, stroke/infarction) or cognitive complications (cognitive decline or memory deficits). There was, however, 1 wound complication (infection but no CSF fistula), and 7 motor complications (2 motor weakness, 2 dyskinesias, 1 swallowing difficulty, and 2 dysphasia).

There was no statistically significant association between treatment modality and complications (p-value=0.127). Although this difference did not reach statistical significance, the higher complication rate observed with subthalamotomy may be clinically relevant in resource-limited settings and warrants caution. In our sample of 40 patients, no mortalities were encountered during the study period.

## Discussion

In this quasi-experimental study of 40 patients, both pallidotomy and subthalamotomy significantly improved UPDRS Part III scores at 3 months, with no statistically significant difference between the groups. Complications, however, were more frequent in the subthalamotomy group, though the difference was statistically insignificant. The modern surgical treatment of choice for PD is Deep Brain Stimulation of the STN, but lesioning is still performed and is a valuable option in non-affording populations.[12] Although the upfront cost for lesional techniques is comparable to deep brain stimulation, AL Green & Kalhoro et al reported cost-effective results of pallidotomy (especially unilateral)

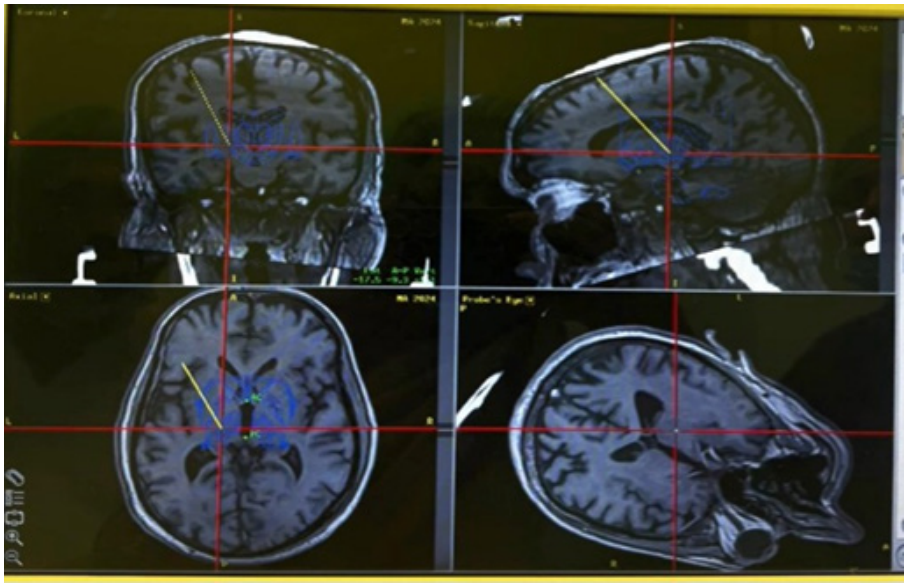


**Figure 1.** Preoperative stereotactic MRI-based target planning showing localization of the globus pallidus internus (GPi) and subthalamic nucleus (STN) for ablative surgery in Parkinson's disease. Red lines: marking target at point of intersection. Yellow line: marking trajectory from skull surface site to ablative target.

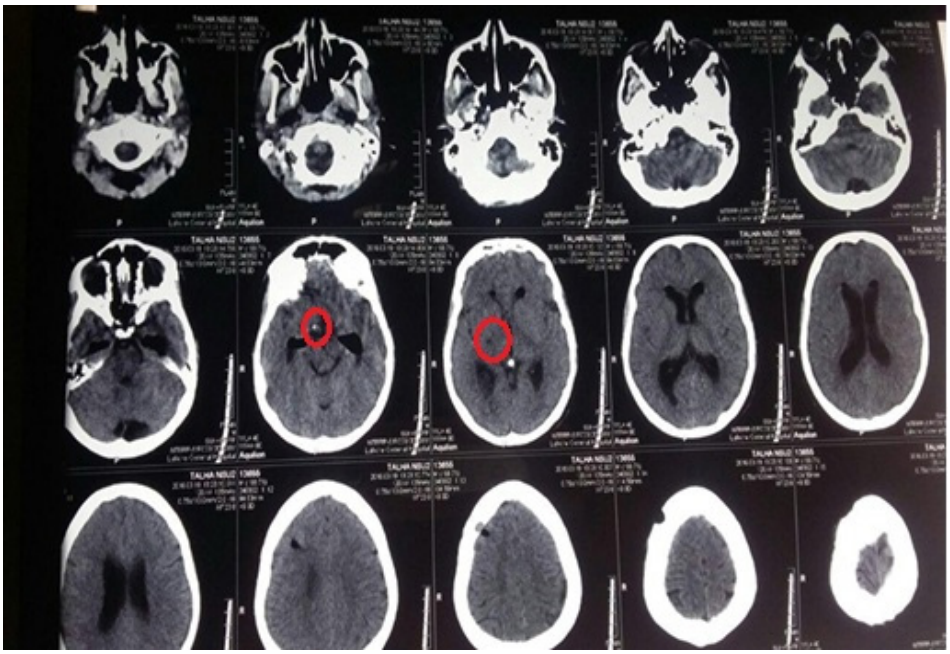


**Figure 2.** Postoperative CT scan following pallidotomy demonstrating the stereotactic lesion within the globus pallidus internus (encircled red), obtained to confirm target placement and exclude postoperative complications.

secondary to improvement in UPDRS score, reduced need for medication, and fewer postoperative complications.[13,14] Thus, these lesioning techniques serve as a viable alternative to the gold standard in the non-affording population of Pakistan.

Traditionally, pallidotomy was the preferred lesioning procedure for PD, but gradually, subthalamotomy started emerging as a potential alternative. In 1997, two separate pilot studies by Gill et al and Obeso et al were conducted to check the safety and efficacy of subthalamotomy, and the results were very encouraging. Both studies concluded that subthalamotomy can be done without any noticeable side effects.[15,16] Alvarez et al described their series of 11 patients

in 2001, in which they showed significant improvement in the symptoms at 6 months without many complications except in one patient who had dyskinesias.[9] Su et al in 2002 described subthalamotomy as a safe procedure thatameliorates all the symptoms of Parkinson's disease without significant complications.[11]
Laitinen et al. (1992) observed in 92% of 38 patients undergoing pallidotomy that the symptom of rigidity had nearly completely abated, and Alvarez et al. described approximately 75% improvement in contralateral limb rigidity following subthalamotomy.[17] A study showed larger improvements in the off-drug phase in the STN group compared with the GPi group in the mean change in UPDRS motor examination scores (20.3±16.3 vs 11.4±16.1). It suggests that STN is the preferred target for DBS in patients with advanced Parkinson's disease.[18] But there was no comparative data to ascertain the efficacy of lesioning in these two nuclei.

In this study, Pallidotomy was compared with the STN lesioning to determine the more effective technique in terms of improvement in UPDRS and associated with fewer complications. Baseline disease severity varied across patients; however, both procedures resulted in significant improvement in overall motor function as reflected by UPDRS Part III scores. In this study, in terms of UPDRS, the improvement was 42% and 40% in the pallidotomy and subthalamotomy groups, respectively, at 3-month follow-up.[18] Previously described studies have yielded results comparable to these findings. Alvarez in 2001 described a 50% improvement in UPDRS postoperatively.[7]

Dogali et al in 1995 described 60% improvement after pallidotomy.[8] Complications reported didn't reach statistical significance, but were more frequent in the subthalamotomy group (35%) as compared with the pallidotomy group (10%). This is in accordance with previous studies, which showed that complications such as speech difficulties and swallowing difficulties, along with dyskinesias, are related to STN lesioning.[19] Similar findings were reported by Alvarez et al. (2009), who observed higher rates of speech and swallowing disturbances following unilateral subthalamotomy.[20] In contrast, studies evaluating pallidotomy, including the randomized trial by Vitek et al. (2003), have demonstrated comparatively lower rates of procedure-related motor and bulbar complications.[21]

Some studies comparing the outcomes of lesioning techniques and DBS have concluded that although STN-DBS offers long-term benefit and medication reduction lesioning procedures, particularly unilateral, offer greater motor improvement.[22,23] A recent systematic review and metanalysis showed that unilateral lesioning offers comparable short-term improvement in UPDRS motor scores, with lower device-related complications, although DBS remains superior for bilateral symptom control.[23] These findings support the continued role of ablative surgery where DBS is unavailable or unaffordable.

Overall, this study adds practical, real-world evidence comparing subthalamotomy and pallidotomy for Parkinsonian rigidity in a resource-limited setting, reinforcing the role of ablative surgery as a viable and relatively cost-effective option when deep brain stimulation is not feasible. Future work should include larger, preferably randomized multicenter studies with longer follow-up, broader motor and non-motor assessments, quality-of-life measures, and systematic evaluation of cognitive and psychiatric outcomes to better define the place of these procedures in modern Parkinson's disease surgery. For a resource-limited setting like Pakistan, pallidotomy and subthalamotomy may be clinically and more economically accessible options for patients with severe symptoms of PD.

## Limitations

This study has several limitations that should be considered and addressed in future research. The relatively small sample size reduces statistical power and increases the risk of selection bias. The non-randomized convenience allocation of patients into either group increases the risk of sampling bias, and in future studies, this could be mitigated by performing subgroup analysis. There was only a single blind observer for calculation of the UPDRS score, and the inter-rater variability was not controlled for this study. Being a single-center study with a marked gender imbalance further limits the generalizability of our findings to broader Parkinson's disease populations. In addition, the short follow-up period of 3 months and reliance on UPDRS Part III motor scores alone preclude comprehensive assessment of long-term outcomes, non-motor symptoms, and quality of life. Additionally, improvement in motor scores does not necessarily reflect true functional recovery in daily activities or improved quality of life. Finally, as all procedures were performed by a limited number of surgeons, possible operator bias cannot be excluded.

## Conclusion

The study shows that both the lesioning techniques are equally effective in reducing the rigidity in patients of Parkinson's disease, but complications associated with subthalamotomy are more common compared to pallidotomy, although not statistically significant.

**Authors' contributions:** OAA contributed to study conception, design, methodology, and drafting of the manuscript. UA conducted the literature review and contributed to the writing of the discussion. RAK performed the statistical analysis and contributed to data interpretation. AJ contributed to the interpretation of results. TA was responsible for data acquisition. SSHS and KM contributed to data analysis and quality assurance. All authors critically reviewed and approved the final manuscript and agree to be accountable for the integrity and accuracy of the work.

**Conflict of Interest:** None to declare

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**Data Availability Statement:** The data that support the findings of this study, apart from the data already presented in the results section, are available from the corresponding author upon reasonable request.

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