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The Role of Deep Brain Stimulation in Parkinson's Disease: Clinical Outcomes and Limitations

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Abstract: Deep brain stimulation (DBS) is a minimally invasive technique in which electrodes are implanted in deep areas of the brain to treat neurological pathologies. It is recommended for Parkinson's disease, obsessive-compulsive disorder, essential tremors, epilepsy and dystonia. The main symptoms of Parkinson's disease, such as bradykinesia, tremors, repetitive stiffness and weakness in arms and legs, are greatly reduced after the deep brain stimulation. For Parkinson's patients who are unresponsive to medication, deep brain stimulation is a gold standard. The immediate effectiveness in reducing the symptoms, the minimally invasive procedure and the fewer postoperative complications are the highlights of this specific surgical procedure, which make it the best choice for the surgeon as well as for the patient. The postoperative period is short, and the patient recovers within weeks and comes to routine within a month. This surgery is performed frequently for patients with stage 4 Parkinson's disease in the department of Neurosurgery and Neuro-rehabilitation at Samarkand State Medical University, Uzbekistan. A total sample size of 68 reports in the year 2024, which consisted of 24 consecutively referred patients for DBS were used to obtain data for examination of age, gender and subtype. The results of our study showed that DBS was conducted more in the elderly and male population. This article also explores the clinical outcomes and limitations of DBS in patients with Parkinson's disease, evaluating the effectiveness, complications and potential risks to be considered. Although DBS seem to be the safest solution for Parkinson's disease, further advancements are still required to enhance therapeutic precision and minimize adverse effects.

Keywords: Deep Brain stimulation, neurosurgery, electrode implantation, Parkinson's disease, clinical outcomes

INTRODUCTION

Parkinson's disease is a neurodegenerative disease affecting more than 11.7 million people worldwide [1]. In recent years, the number of people diagnosed with Parkinson's disease in Uzbekistan has been increasing, with a total of 563 deaths recorded in the year 2020. Parkinson's disease is mainly due to degeneration of dopamine producing neurons in substantia nigra of the brain, affecting both motor and non-motor systems. Motor symptoms include bradykinesia, rigidity, resting tremor, and postural instability, while non-motor symptoms include behavioral and neuropsychiatric problems. While pharmacological treatments are mainly used for symptomatic treatment, its long term use can result in motor fluctuations and dyskinesia. In patients unresponsive to medications, deep brain stimulation is an important surgery to consider [2].

The procedure involves using a stereotaxic apparatus to make precise markings on the skull in a patient under anesthesia to create a burr hole, which is used to reach the deep brain areas such as the posterior ventrolateral nucleus of thalamus. After the implantation of electrodes bilaterally in deep brain areas, the second stage of surgery is proceeded with the creation of a pocket in the subcutaneous tissue on the upper third of the right breast. A pulse generator is inserted in this pocket, which is connected to the electrodes. The pulse generator is also connected to a device through which it is monitored. The pulse generator generates impulses, and electrodes stimulate the deep brain areas, thereby reducing the symptoms of Parkinson's disease. The dopamine levels are regulated using a Medtronic tablet. The patient gets discharged within a week and returns to normal activities in two months.

This article aims to explore deep brain stimulation in patients with stage 4 Parkinson's disease according to Hoehn and Yahr Scale, while emphasizing its benefits and long-term effects on the patient's health. This article also highlights postoperative complications such as intracranial hemorrhage, infection, lead misplacement and hardware related complications. There is an emphasis on the variations in age and gender in both male and female populations, based on the 24 consecutive patients who had undergone DBS at our center.

Materials and Methods:

This systematic review on case based study involves the operational database and medical records of patients being treated at Neurosurgery and Neuro-rehabilitation at Samarkand State Medical University's scientific and practical center in Uzbekistan. We have analyzed 68 cases, of which 24 patients had undergone DBS, from July to November in the year 2024 to obtain the data. The criteria for selection of patients included patients of age group 35 to 70 years with idiopathic Parkinson disease of stage 4 according to Hoehn and Yahr scale. These patients had already undergone levodopa therapy, but still showed some significant motor complications [3]. Patients with severe cognitive decline and psychiatric decline were excluded [4]. All the data collected is ethically approved by authorities. Confidentiality is maintained and all rights are observed.

The data collected was used to study parameters like demographics, Parkinson's disease subtypes, clinical outcomes and limitations. Demographics includes age at the time of surgery in both male and female patients, while showcasing a gender disparity in the surgery conducted [5]. Three main subtypes of Parkinson's disease studied includes tremor dominant (where resting tremor is prominent symptom), akinetic-rigid (where bradykinesia and rigidity are prominent) and mixed type (in patients showing a combination of tremor, rigidity and bradykinesia) [6]. We have also analyzed motor improvement and medication reduction in patients after DBS [7]. This article also looks at the complications and limitations of deep brain stimulation on a long-term basis [8].

Results:

We studied 24 case reports from July to November of 2024, all of which showed tremendous success with relief of symptoms. The patients are recommended to continue taking their drugs prescribed for Parkinson's disease, but in reduced doses. They are also asked to return to the hospital for a procedure of activating the stimulators and coordinating the patient's movements. We have analyzed the age, sex and subtypes of Parkinson's disease in these patients. The age of patients varied from 35 to 69 years, with the median age being 59 years [9]. The median age of male patients is 55 years, whereas that for female patients is 62 years (Figure 1). We observed that out of 24 cases, 15 were male patients and 9 were female patients, which shows a clear discrepancy in gender norms (Table 1) [10]. All the patients had stage 4 of Parkinson's disease with three subtypes prominently seen, where 9 patients had tremor dominant subtype (37.5%), 8 have rigid dominant subtype (33.3%) and 7 patients had mixed tremor-rigid subtype (29.2%) (Table 1) (Figure 2) [11]. An important observation made is that all the patients who had undergone deep brain stimulation have shown full recovery, with little or no complications reported till date.

VARIABLE	N=24	PERCENTAGE
Male	15	62.5
Female	9	37.5
Tremor-dominant (TD) subtype	9	37.5
Akinetic-rigid (AR) subtype	8	33.3
Mixed subtype	7	29.2

Table 1. Patient demographics and Parkinson's disease subtypes

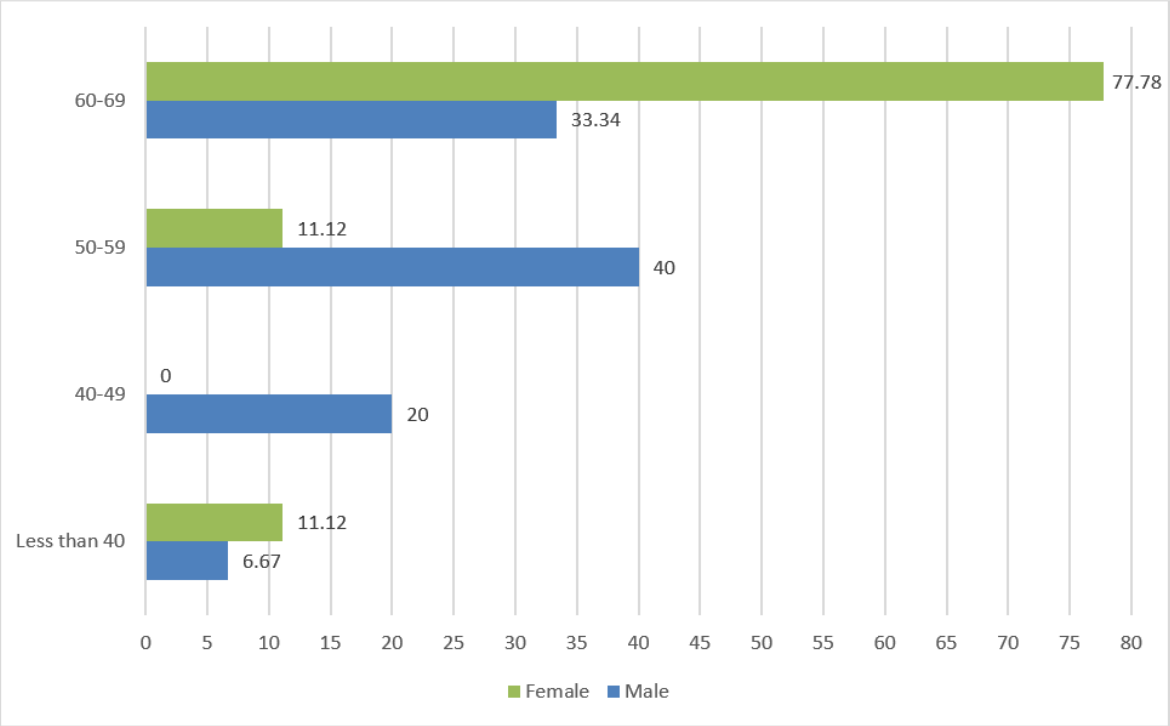

Figure 1. Age and gender distribution of patients undergoing DBS for Parkinson's disease (in percentage)

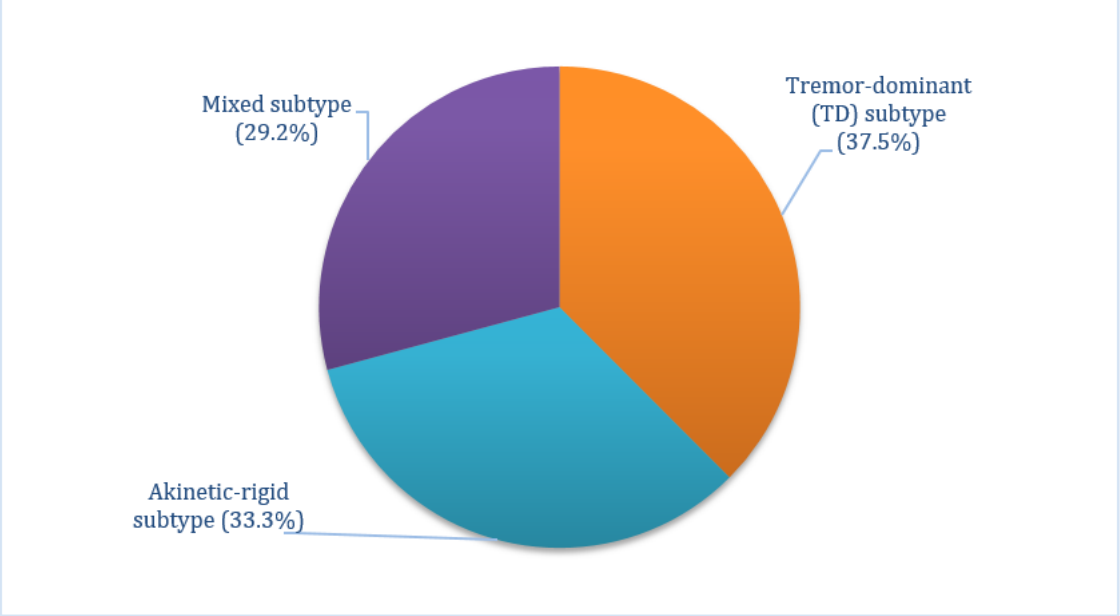

Figure 2. Parkinson's Disease subtypes (in percentage)

Discussion:

Parkinson's disease is a neurodegenerative disease that results in motor and non-motor symptoms. It is mainly seen in the elderly, with a predominance in male population [12]. The patients undergoing DBS had a stage 4 form of Parkinson's disease (Hoehn and Yahr scale), where the symptoms were severe and patients had difficulty in walking and standing independently. The three subtypes analyzed in this report was tremor dominant, rigid dominant and mixed tremor-rigid subtypes. Further, we have observed that in the initial stages, the motor symptoms can be effectively treated using medications, with the most common one being levodopa [13]. But in advanced cases, deep brain stimulation is a great option for those not responding well to drugs alone.

DBS have proven to be a safe and highly effective treatment option for motor symptoms resulting in a marked reduction in rigidity, tremor and bradykinesia. It also allows for a reduction in dosage of medication taken, which can minimize further drug-related side effects and improve overall well-being of the patients. This has been seen in patients recovering from DBS in our department. Although highly advantageous, DBS does not completely halt the progression of Parkinson's disease [14]. It also requires strict criteria for patient selection as those with idiopathic Parkinson's disease who experience significant motor fluctuations but do not have severe cognitive impairment or psychiatric disorders have proved to be the ideal candidate [15]. Potential risks from the surgery include infection, stroke, bleeding and equipment failure [16]. Along with these complications, the high cost may deter many patients from this procedure [17]. This proves that further advancements are required in the fields of safety, accuracy and accessibility of deep brain stimulation.

Conclusion:

Currently, there is no complete cure found for Parkinson's disease other than for its symptomatic treatments. Deep brain stimulation, although very effective in patients not responding adequately to medications, has its own limitations. By sending electrical impulses to targeted brain regions, it can reduce the motor symptoms of Parkinson's disease, but it's effect on non-motor symptoms varies in patients. It requires a very strict patient selection for optimal outcome. Other complications such as defects in machinery, surgical errors and infections also pose potential risk to the patients. In this article, we have observed that all patients who had undergone deep brain stimulation had shown less complications. We have also taken into account the age and gender disparities in patients undergoing deep brain stimulation. To sum up, deep brain stimulation is a promising solution to improve the quality of life in patients with Parkinson's disease, but ongoing advancements and further research can make it more efficient and accessible.

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