IJMA

INTERNATIONAL JOURNAL OF MEDICAL ARTS

VOLUME 6, ISSUE 6, JUNE 2024

P- ISSN: 2636-4174
E- ISSN: 2682-3780

Available online at Journal Website
https://ijma.journals.ekb.eg/
Main Subject [Neurosurgery]

Original Article

Unilateral Stereotactic Radiofrequency Thalamotomy for Tremors in Parkinson's Patients

Ahmed Hamed Elkishky *, Mostafa Elmaghraby, Elsayed Abd Elrahman Emara El Mor

Department of Neurosurgery, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

ABSTRACT

Article information

Received: 02-07-2023

Accepted: 14-05-2024

DOI: 10.21608/IJMA.2024.220614.1726.

*Corresponding author
Email: dr.ahmadelkishky@gmail.com

Citation: Elkishky AH, Elmaghraby M, El Mor EAE. Unilateral Stereotactic Radiofrequency Thalamotomy for Tremors in Parkinson's Patients. IJMA 2024 June; 6 [6]: 4559-4565. doi: 10. 21608/IJMA.2024.220614.1726.

Background: Parkinsonism is a clinical syndrome characterized by tremors, bradykinesia or akinesia, rigidity, and postural instability in varying proportions. Important stereotactic techniques were brought into movement disorder surgery by Spiegel and Wycis.

Aim of the work: Assessment of clinical outcomes and improvements in the quality of life after stereotactic radiofrequency thalamotomy for Idiopathic Parkinson's disease [PD] cases.

Patients and Methods: A prospective cohort study included 30 patients with idiopathic PD subjected to unilateral stereotactic radiofrequency thalamotomy. The primary outcome is the Unified PD Rating Score [UPDRS].

Results: There was a statistically significant variation in tremors among the individuals under study [p-value 0.001]. One patient [3.3%] had a grade I condition, seven [23.3%] had a grade III condition, and 22 [73.3%] had a grade IV condition. Following surgery, there were 12 cases [40%] with grade I tremors, 9 [30%] with grade II tremors, and 9 patients [30%] with no tremors at all. At 12 months Following surgery, there were 15 patients [50%] with grade I tremors, 7 [23.3%] with grade II tremors, and 8 [26.7%] with no tremors.

Conclusion: Thalamotomy can improve the tremor totally in 27% of patients [9 patients] and partially in 74% [21 patients], but it cannot stop the course of PD. For many PD patients, longer years without tremor may be possible by selectively enrolling cases, documentation of neurological impairments, localizing and creating lesion in surgery with pinpoint accuracy, and prudent after-surgery antiparkinsonian medication administration.

Keywords: Parkinson Disease; Tremor; Radiofrequency Therapy.

INTRODUCTION

Parkinsonism is a clinical syndrome characterized by tremors, bradykinesia or akinesia, rigidity, and postural instability in varying proportions [1]. Most cases of Parkinsonism seen in clinics are those with PD, which is the most prevalent primary or idiopathic form of Parkinsonism [2, 3]. PD is a degenerative condition brought on by the death of nerve cells in the region of the brain that regulates movement, the substantia nigra [4].

Presently, the severity of Parkinson's tremor is measured by the Unified PD Rating Scale [UPDRS], which ranges from 0 to 4, with 0 being normal, 1 being slight, 2 being mild, 3 being moderate, and 4 being severe [5].

Important stereotactic techniques were brought into movement disorder surgery by Spiegel and Wycis [6]. These methods were eventually improved to the point where it was possible to target particular subcortical structures with millimeter-level accuracy. Following that, surgeons began concentrating on performing thalamotomy and pallidotomy procedures [7].

Medical treatments can help PD in its early stages [8]. Due to the negative effects of levodopa therapy, surgical treatments such as thalamotomy, pallidotomy and subthalamotomy have become more popular [9, 10]. Today's available lesioning techniques comprise invasive techniques like radiofrequency [RF], thermoablation, and laser interstitial thermal therapy [LITT]. Lesioning technologies have since developed, and less intrusive techniques like stereotactic radiosurgery [SRS with radiofrequency], high-intensity focused ultrasound [HIFU], thermo-ablation, and others are frequently utilized [9, 11].

Thalamotomy, a neurosurgical procedure that involves the precise destruction of a small area in the thalamus of the brain, has historically been utilized as an effective treatment for alleviating tremors in patients with Parkinson's disease [1, 10]. Despite its reduced utilization in modern practice, thalamotomy remains a valuable therapeutic option that warrants further examination and consideration in the context of individualized treatment strategies for Parkinson's patients experiencing debilitating tremors

The aim of this study is to evaluate idiopathic PD patients' clinical outcomes and improvements in their quality of life after stereotactic radio-frequency thalamotomy.

PATIENTS AND METHODS

Study design: Thirty patients with unilateral stereotactic radiofrequency thalamotomy for idiopathic PD were the subject of this prospective investigation. The study was conducted between February 2022 and May 2023 at the Neurosurgery Department of Al-Azhar University Hospitals, Cairo.

Inclusion criteria: The existence of idiopathic PD, good "on" function from medication, principal symptoms not well controlled, refractory tremors, frequent or prolonged "off" periods, and tremor-related incapacity during off-time.

Exclusion criteria: More than 80 years of age, coagulopathy, hepatic dysfunction, severe hypertension, Parkinson plus or atypical Parkinson disease, progressive supranuclear palsy, Corticobasal ganglionic degeneration, and multiple system atrophy, severe impairment during the best "on", dementia, psychosis, depression, or patients who experience various types of tremors.

Data collection

All cases are submitted to a thorough history, which includes information about their occupation, smoking habits, and any co-existing medical issues. Chronic illnesses such as diabetes and hypertension, chronic liver or kidney disorders, heart issues, neurological complaints, and reports of prior injuries or procedures are all checked. Along with a complete medication history, the duration between the disease's inception and diagnosis, medication compliance, and the occurrence of medication problems.

General assessments, complete neurological evaluation. By video recording the Unified PD Rating Score [UPDRS] during off-state preoperatively, early postoperatively, and 12 months postoperatively, we evaluated the severity of PD.

Laboratory work: CBC, INR, AST, ALT, serum creatine, and ABO typing are preoperative lab tests. Using radiographic imaging, a CT scan of the brain can be used to look for calcifications, anomalies in the skull bone, and signs of previous craniotomies or strokes.

To screen for secondary pathology and assess the basal ganglia for any anomalies, such as inequality or atrophy, a brain MRI is used. To assess the anterior-posterior commissure reference [AC-PC] and see targets, using high-resolution MRI T1, T2, SWI, and PDI protocols DICOM format.

Surgical procedures

Consent was given before surgery, including information about the procedure's results and any consequences. Prior to the morning of surgery, medications were stopped at midnight to allow for a better evaluation of the operation's outcome. Before the procedure, we collected a high-resolution T1, T2, SWI, and PDI protocol Brain MRI on a DICOM format to precisely localize the anterior commissure-posterior commissure plane [AC-PC plane], as well as to identify the VIM, which is situated about 14 mm laterally to the IC line and 25% of the AC/PC line ventral to the PC. The LEKSELL stereotactic system, Elekta instrument, Sweden, is then attached to the patient's head while being balanced, and the frontal pins are put above the lateral third of the eye brow. Then, high-resolution CT after the installation of CT fiducials is acquired in DICOM format.

After that, we fused MRI and CT using brain navigation and localize the target of interest and trajectory by X, Y, and Z. The VIM was targeted. Under Local anesthesia, a skin incision is done above the selected entry point, which was guided by the navigation. To avoid the lateral ventricle, sulci, or any blood vessels, a burr hole is made, and the stereotactic electrode is introduced towards the target. For macrostimulation and lesion generation, we employed the Neuro N50 lesion generator [Inomed Instruments, Emmendingen, Germany]. Regular stimulations at 50 Hz, 0.4 mA, and 2 Hz, 2.0 mA, was also be employed to prevent any potential invasion of the optic tract or internal capsule. Through a burr hole 3 cm laterally to the midline and immediately anterior to the coronal suture, guided by the navigation, the electrode [2 mm in diameter, 2-mm length bipolar active tip] was inserted towards the predicted target. The progression of lesions was based on changes in the primary parkinsonian symptoms. The electrode was heated for 30 seconds each to 45, 50, 60, 70, and 80 °C. Continuous monitoring of muscular activity, visual fields, and mental state was done while the electrodes were being heated. The stimulation and lesion paradigm were then be performed once the electrode has been inserted 2 mm higher. Depending on the clinical response of tremor, rigidity, and velocity of extremity motion, more lesion extension was carried out. To check the lesion or lead location and rule out hemorrhage, routine CT scans was obtained. Follow-up following surgery: Unified PD Rating Scale [UPDRS] postoperative and 12-month follow-up and clinical assessment of tremors.

Statistical analysis: Statistical Program for Social Science [SPSS] version 24 was used to analyze the data. Data that was quantitative was presented as the mean SD. The frequency and proportion of the qualitative data were expressed. To compare pre- and post-operative means, the Wilcoxon signed-rank test was used. Chi-square test was used to compare categorical variables. The level of significance was set at $P < 0.05$.

RESULTS

The age of studied patients ranged from 37 to 77 years old; the average age of all patients in the study was 59.2 ± 10.02 years. The patients under study were divided into 18 males [60%] and 12 females [40%] by sex.

Six patients [20%] had DM, and six [20%] had HTN. In terms of the length of the symptoms, the average across all patients was 8.1 ± 3.8 years, ranging from a minimum of 3 years to a maximum of 20 years. Regarding handedness, 5 patients [16.7%] were left-handed and 25 patients [83.3%] were right-handed among the patients under study. In terms of the handedness that was affected, the right hand was affected in 16 [53.3%] and the left hand in 14 [46.7%] of the patients.

UPDRS 3 in the individuals under study exhibited a statistically significant difference [p-value 0.001]. It was 45.7 ± 10.2 prior to surgery, 33.03 ± 8.4 following surgery, and 33.3 ± 8.9 a year later [Table 1].

Table [2] displays the statistically significant differences in ADL among the patients under study [p-value 0.001]. It was 31.8 ± 7.5 prior to surgery, 25.9 ± 3.5 following surgery, and 24.93 at one year later.

Table [3] displays the statistically significant variation in tremors among the individuals under study [p-value 0.001]. One patient [3.3%] had a grade I condition, seven [23.3%] had a grade III condition, and 22 [73.3%] had a grade IV. Following surgery, there were 12 patients [40%] with grade I tremors, 9 [30%] with grade II tremors, and 9 [30%] with no tremors at all. After 12 months, there were 15 [50%] with grade I tremors, 7 [23.3%] with grade II tremors, and 8 [26.7%] with no tremors.

The post-operative problems for each patient included in the study are listed in table [4]. While there were no patients [0%] with DCL or intra-cerebral hemorrhage, there were three patients [10%] who experienced dysarthria, three [10%] who experienced temporary disorientation, one [3.3%] who experienced deviation, and one [3.3%] patient who experienced contralateral side weakness.

Table [1]: Comparisons of UPDRS 3 throughout the study

UPDRS 3	Follow-up [n=30]			Stat. test	P-value
	Pre-op	Post-op	After 12 months		
Mean ± SD	45.7	33.03	33.3	24.8	< 0.001
	10.2	8.4	8.9		

Table [2]: Comparisons of ADL throughout the study

ADL	Follow-up [n = 30]			Stat. test	P-value
	Pre-op	Post-op	After 12 months		
Mean ± SD	31.8	25.9	24.9	16.9	< 0.001
	7.5	3.5	3.1		

Table [3]: Comparisons of tremors throughout the study

Tremors	Follow-up [n = 30]						Stat. test	P-value
	Pre-op		Post-op		After 12 months			
	No.	%	No.	%	No.	%		
No	0	0%	9	30%	8	26.7%	$X^2 = 86.6$	< 0.001
Grade I	1	3.3%	12	40%	15	50%		
Grade II	0	0%	9	30%	7	23.3%		
Grade III	7	23.3%	0	0%	0	0%		
Grade IV	22	73.3%	0	0%	0	0%		

Table [4]: Description of post-operative complications in all examined cases

		Studied patients [n = 30]	
Complications	Weakness	1	3.3%
	Dysarthria	3	10%
	Disturbed conscious level	0	0%
	Transient confusion	3	10%
	Deviation	1	3.3%
	Intra-cerebral Hemorrhage	0	0%

DISCUSSION

Before the discovery of levodopa, the only treatment for the symptoms of PD was surgical ablation of several brain targets. The physio-pathological theories of **Hassler *et al.*** [12] and Cooper's accidental discovery that closure of the anterior choroidal artery improved patients' clinical conditions sparked interest in the basal ganglia. Despite variations in etiology and pathogenesis, nucleus ventralis intermedius [VIM] thalamotomy is beneficial for most forms of tremor to varying degrees [1].

Stereotactic brain surgery was first performed in 1947 by **Spiegel *et al.*** [6]. Thalamotomy alone has historically been utilized as a PD maneuver. However, tremors were handled alongside stiffness and bradykinesia following Leksell's evolutionary introduction to the GPI [13]. Long-term research on isolated thalamotomy has demonstrated that rigidity-related disabilities persist in the patients. Additionally, studies that suggested that a single lesion in the GPI could regulate tremors and rigidity were later proven to be ineffective [14].

We wanted to determine how stereotactic radiofrequency thalamotomy affected cases with idiopathic PD in terms of clinical outcome and life quality. In 30 patients with unilateral stereotactic radiofrequency thalamotomy and idiopathic PD, we did the current prospective investigation.

Elkazaz *et al.* [13] found success in enhancing patients' UPDRS in their series of studies. After one month, the average UPDRS consistency of tremors significantly improved from 3.53 to 0.75. Non-significant increases at 6 and 12 months [1.23, and 1.72 were seen]. After 24 months, with an average improvement of 1.62, the overall constancy of tremors increased in up to 75% of cases; however, in our investigation, a statistically significant difference [p-value 0.001] in UPDRS was seen. It was 45.7 ± 10.2 prior to surgery, 33.03 ± 8.4 following surgery, and 33.3 ± 8.9 a year later. According to **Linhares and Tasker** [15], the thalamotomy surgery improved tremor suppression in PD by 75 percent in the case of upper limb tremors and 73% in the case of lower limb tremors. In order to improve patients' functional condition and control PD, **Fayed *et al.*** [16] found that pallidotomy combined with thalamotomy performed better than pallidotomy alone. The presence of difficulties can be explained by the fact that smaller thalamic lesions should result in fewer complications than those seen with previous, larger lesions. The patient's age and overall neurological condition do, however, play a role in postoperative surgical problems following thalamotomy. Young cases with unilateral tremor and no signs of dementia, speech, or gait impairment make the greatest surgical candidates for stereotactic thalamotomy; however, these patients are rarely recommended for the procedure because the majority of patients have at least partial tremor control with carbidopa or levodopa. In our knowledge, the majority of patients who are recommended to undergo thalamotomy are older than 60 and have PD that is in a fairly advanced stage. These patients are more likely to experience postoperative issues.

In order to properly monitor issues, we have made it a policy to meticulously record before- and after-surgical speech, language, and cognitive performance, besides the neurological evaluation. The continuation of tremors after lesioning the GpI alone has been attributed to a number of factors since the GpI lesion does not directly disconnect the rubrothalamocortical loop and could even make things worse by disinhibiting the reticulospinal system. According to **Locano *et al.*** [17], combined Vim and GPi lesioning can effectively treat a wide spectrum of PD signs right away with little to no danger to the patients.

The rationale behind targeting the ventral intermediate nucleus [VIM] lies in the pivotal role of the VIM nucleus in motor control and tremor generation. The VIM nucleus is a key component of the motor thalamus and is known to be a crucial relay station in the tremor circuitry of the brain. By precisely targeting and lesioning the VIM nucleus using stereotactic radiofrequency ablation, it is possible to disrupt the aberrant oscillatory activity within the tremor network, leading to a reduction in tremor severity and frequency. Furthermore, the VIM nucleus is located in close proximity to the motor thalamic territory, making it a prime target for interventions aiming to modulate motor symptoms such as tremors in Parkinson's disease. The specific and selective targeting of the VIM nucleus allows for the mitigation of tremor-related dysfunction while preserving other thalamic functions, thus offering a focused and effective approach to tremor management in Parkinson's patients.

According to **Fox *et al.*** [18]'s findings, stereotactic thalamotomy is a safe and effective method for treating PD patients who have chronic levodopa resistance. Furthermore, the preoperative drug-induced dyskinesias of two patients who were being watched carefully significantly improved. In our study, temporary complications included dysarthria in 3 patients [10%], transient confusion in three patients [10%], deviation in one patient [3.3%], and contralateral side weakness in one patient [3.3%], while there were no permanent complications, such as DCL or intra-cerebral hemorrhage, in the patients who were being studied.

Accurate placement of lesions within the ventralis lateralis nucleus is essential for successful operating outcomes and the prevention of sequelae. Incorrectly positioned lesions or very big lesions are frequently the cause of complications. Because of the involvement of the posterior limb of the internal capsule, contralateral hemiparesis can be caused by a lesion that is placed too laterally inside the ventralis lateralis nucleus. A lesion that is too posterior may create dysesthesias or deficits in the contralateral hemisensory limb because it involves the ventralis posterior nucleus. This is because of the involvement of this nucleus. It is possible for the contralateral limb to develop postoperative hemiballismus since the lesion extended inferiorly to the subthalamic area. If a lesion is positioned excessively medially, it may impact the fornices and cause memory loss, especially if it is bilateral. Occasionally, despite the disappearance of tremor and the preservation of complete strength and sensation, cases have experienced contralateral neglect or limb dyspraxis. Others have claimed that thalamotomy may help patients who remain on Sinemet for rigidity, bradykinesia, or contralateral tremor avoid dyskinesias of the limb that are tremor-free [19]. These findings support the use of thalamotomy as a therapy for medically resistant tremor and are congruent with findings from other series that were gathered before the time of carbidopa and levodopa [20].

The findings of this study can be Integrated within the existing literature on thalamotomy for PD tremor. Our results demonstrate a significant reduction in tremor severity and frequency following thalamotomy, aligning with previous research indicating the efficacy of thalamotomy in ameliorating tremors in Parkinson's disease. These outcomes are consistent with several studies that have reported favorable outcomes with thalamotomy, highlighting its role as a valuable therapeutic option for addressing tremor-related symptoms in PD patients [1, 13, 15,]. The observed improvements in tremor control post-thalamotomy underscore the potential of this intervention in providing symptomatic relief and enhancing quality of life for individuals living with Parkinson's disease. By corroborating and extending upon the findings of prior investigations, our study contributes to the growing body of evidence supporting the utility and effectiveness of thalamotomy as a targeted treatment approach for managing tremors in PD patients.

While it is true that thalamotomy is less commonly employed today compared to other surgical interventions such as deep brain stimulation [DBS], it continues to hold significance in the realm of neurosurgery for Parkinson's disease. Thalamotomy offers unique advantages, such as its immediate and often significant reduction in tremors without the need for long-term hardware implantation or frequent programming adjustments associated with DBS. Additionally, thalamotomy is a one-time procedure that can provide long-lasting symptomatic relief, making it a compelling choice for patients who may not be suitable candidates for DBS or who prefer a more straight-forward surgical approach.

Conclusion

Thalamotomy can improve the tremor totally in 27% of patients and partially in 74%, but it cannot stop the course of PD. Longer years without tremor may be possible for many Parkinson's disease patients if cases are carefully chosen, neurological impairments are correctly recorded prior to surgery, surgical localization and lesion formation is precise, and antiparkinsonian drugs is administered prudently after surgery. Despite being a successful method, not many studies have used it. It has shown potency and poses little risk to patients. We recommend doing case-control studies to evaluate this approach.

Conflicts of interest: None.

REFERENCES

1. Niranjan A, Jawahar A, Kondziolka D, Lunsford LD. A comparison of surgical approaches for the management of tremor: radiofrequency thalamotomy, gamma knife thalamotomy and thalamic stimulation. Stereotact Funct Neurosurg. 1999;72[2-4]:178-84. doi: 10.1159/000029723.

2. Bower JH, Maraganore DM, McDonnell SK, Rocca WA. Incidence and distribution of parkinsonism in Olmsted County, Minnesota, 1976-1990. Neurology. 1999;52[6]:1214-20. doi: 10.1212/wnl.52.6.1214.

3. Handforth A, Homanics GE, Covey DF, Krishnan K, Lee JY, Sakimura K, Martin FC, Quesada A. T-type calcium channel antagonists suppress tremor in two mouse models of essential tremor. Neuropharmacology. 2010;59[6]:380-7. doi: 10.1016/j.neuropharm.2010.05.012.

4. Kumar R, Lozano AM, Kim YJ, Hutchison WD, Sime E, Halket E, Lang AE. Double-blind evaluation of subthalamic nucleus deep brain stimulation in advanced Parkinson's disease. Neurology. 1998 Sep;51[3]:850-5. doi: 10. 1212/wnl.51.3.850.

5. Goetz CG, Tilley BC, Shaftman SR, Stebbins GT, Fahn S, Martinez-Martin P, *et al.*; Movement Disorder Society UPDRS Revision Task Force. Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale [MDS-UPDRS]: scale presentation and clinimetric testing results. Mov Disord. 2008 Nov 15;23 [15]:2129-70. doi: 10.1002/mds.22340.

6. Spiegel EA, Wycis HT, Marks M, Lee AJ. Stereotaxic Apparatus for Operations on the Human Brain. Science. 1947;106[2754]:349-50. doi: 10.1126/science.106.2754.349.

7. Cotzias GC, Van Woert MH, Schiffer LM. Aromatic amino acids and modification of parkinsonism. N Engl J Med. 1967;276[7]:374-9. doi: 10.1056/NEJM196702162760703.

8. Obeso JA, Olanow CW, Nutt JG. Levodopa motor complications in Parkinson's disease. Trends Neurosci. 2000 Oct 1;23[10 Suppl]: S2-7. doi: 10.1016/S1471-1931[00]00031-8.

9. Laitinen LV, Bergenheim AT, Hariz MI. Ventroposterolateral pallidotomy can abolish all parkinsonian symptoms. Stereotact Funct Neurosurg. 1992;58[1-4]:14-21. doi: 10.1159/ 000098965.

10. Tasker RR, Siqueira J, Hawrylyshyn P, Organ LW. What happened to VIM thalamotomy for

Parkinson's disease? Appl Neurophysiol. 1983; 46[1-4]:68-83. doi: 10.1159/000101245.

11. Jourdain VA, Schechtmann G. Health economics and surgical treatment for Parkinson's disease in a world perspective: results from an international survey. Stereotact Funct Neurosurg. 2014;92 [2]:71-9. doi: 10.1159/000355215.
12. Lee DJ, Lozano CS, Dallapiazza RF, Lozano AM. Current and future directions of deep brain stimulation for neurological and psychiatric disorders. J Neurosurg. 2019 Aug 1;131[2]: 333-342. doi: 10.3171/2019.4.JNS181761.
13. Elkazaz MK, Khedr AS, Abdelfattah M. Unilateral combined stereotactic radiofrequency pallidotomy and thalamotomy for Idiopathic Parkinson’s disease. Pan Arab J Neurosurg. 2023 Dec 1;18[2]:139-45. doi: 10.21608/pajn. 2023.204191.1090.
14. OKUN E. Chronic papilledema simulating hyaline bodies of the optic disc. A case report. Am J Ophthalmol. 1962 Jun;53:922-7. doi: 10.1016/0002-9394[62]93012-x.
15. Linhares MN, Tasker RR. Microelectrode-guided thalamotomy for Parkinson's disease. Neurosurgery. 2000 Feb;46[2]:390-5; discussion 395-8. doi: 10.1097/00006123-200002000-00024.
16. Fayed ZY, Radwan H, Aziz M, Eid M, Mansour AH, Nosseir M, *et al*. Combined Unilateral Posteroventral Pallidotomy and Ventral Intermediate Nucleus Thalamotomy in Tremor-Dominant Parkinson's Disease versus Posteroventral Pallidotomy Alone: A Prospective Comparative Study. Stereotact Funct Neurosurg. 2018;96 [4]:264-269. doi: 10.1159/000492229.
17. Iacono RP, Henderson JM, Lonser RR. Combined stereotactic thalamotomy and posteroventral pallidotomy for Parkinson's disease. J Image Guid Surg. 1995;1[3]:133-40. doi: 10.1002/[SICI] 1522-712X[1995]1:3<133::AID-IGS2>3.0.CO;2-B.
18. Fox MW, Ahlskog JE, Kelly PJ. Stereotactic ventrolateralis thalamotomy for medically refractory tremor in post-levodopa era Parkinson's disease patients. J Neurosurg. 1991 Nov;75 [5]:723-30. doi: 10.3171/jns.1991.75.5.0723.
19. Fox AJ, Wanivenhaus F, Rodeo SA. The basic science of the patella: structure, composition, and function. J Knee Surg. 2012 May;25[2]: 127-41. doi: 10.1055/s-0032-1313741.
20. Kelly PJ, Gillingham FJ. The long-term results of stereotaxic surgery and L-dopa therapy in patients with Parkinson's disease. A 10-year follow-up study. J Neurosurg. 1980 Sep;53 [3]:332-7. doi: 10.3171/jns.1980.53.3.0332.

IJMA

International Journal of Medical Arts

Volume 6, Issue 6, JUNE 2024

P- ISSN: 2636-4174
E- ISSN: 2682-3780