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Technology-Based Evaluation in Parkinsonism

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Review

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ABSTRACT

Parkinson's disease is a neurodegenerative disorder characterized by motor and non-motor symptoms that worsen over time. Today, traditional clinical assessment methods are used to monitor disease progression and evaluate treatment responses. However, these methods are subjective and may fail to measure specific conditions. In recent years, thanks to advances in wearable technologies, smart sensors, and data analysis, technology-based approaches to the assessment of patients with Parkinson's disease have gained more attention. With these technologies, objective data can be obtained by monitoring patients' daily activities, motor functions, and symptoms. Motor symptoms such as tremor severity, rigidity, bradykinesia, postural instabilities, freezing phenomenon, and motor parameters of speech impairment can be objectively measured through these technologies. Furthermore, the ability to remotely transmit these data allows patients to be assessed in their own homes and provides continuous feedback to healthcare professionals. This review highlights the importance and potential of technology-based assessment methods in Parkinson's patients and aims to guide future research.

Keywords: Parkinson's, technological measurement, wearable technologies, intelligent sensors

Parkinsonda Teknolojik Tabanlı Değerlendirme

Derleme

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ÖZET

Parkinson hastalığı, motor ve motor olmayan semptomlarla karakterize nörodejeneratif bir hastalıktır ve bu semptomlar zaman içinde kötüleşir. Günümüzde hastalığın ilerleyişini izlemek ve tedavi yanıtlarını değerlendirmek için geleneksel klinik değerlendirme yöntemleri kullanılmaktadır. Ancak bu yöntemler subjektiftir ve belirli durumları ölçmede yetersiz kalabilir. Son yıllarda, giyilebilir teknolojiler, akıllı sensörler ve veri analizindeki ilerlemeler sayesinde parkinson hastalarının değerlendirilmesinde teknolojik tabanlı yaklaşımlar daha fazla dikkat çekmektedir. Bu teknolojiler sayesinde hastaların günlük aktiviteleri, motor fonksiyonları ve semptomları izlenilerek objektif veriler elde edilebilir. Tremor şiddeti, rijidite, bradikinezi, postüral instabiliteler, donma fenomeni ve konuşma bozukluğunun motor parametreleri gibi motor semptomlar bu teknolojiler aracılığıyla objektif olarak ölçülebilir. Ayrıca, bu verilerin uzaktan aktarılabilmesi, hastaların kendi evlerinde değerlendirilebilmesine olanak tanır ve sağlık uzmanlarına sürekli geri bildirim sağlar. Bu derleme, parkinson hastalarında teknolojik tabanlı değerlendirme yöntemlerinin önemini ve potansiyelini vurgulamakta ve gelecekteki araştırmalara rehberlik etmeyi amaçlamaktadır.

Anahtar Kelimeler: Parkinson, teknolojik ölçüm, giyilebilir teknolojiler, akıllı sensörler

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Introduction

Parkinson's disease (PD) is a complex neurodegenerative disorder characterized by typical motor symptoms including bradykinesia, hypo-/akinesis, rigidity, and resting tremor, usually with asymmetric onset.[1] The prevalence and incidence rates for PD in Europe are estimated to be approximately 108-257/100,000 and 11-19/100,000 per year, respectively.[2] In Turkey, the prevalence of PD was determined as 1.2% in a prevalence study conducted in Edirne province in 2022.[3] The incidence of PD increases with age and the majority of individuals are over 60 years of age.[4] Considering that the world population is getting older, the number of individuals with PD may exceed 12.9 million in 2040.[5] In most Parkinson's cases, the disease is idiopathic, but genetic and environmental risk factors also contribute.[6] Age is the most important risk factor for PD. In epidemiologic studies, exposure to pesticides, heavy metals, rural life and farming were listed among the risk factors, while smoking and caffeine consumption were found to be protective.[7] Although PD pathology is usually diagnosed based on motor symptoms, many non-motor symptoms also occur with the disease.[8]

Non-motor symptoms are often prominent and sometimes cause more disability than motor symptoms. The current practice for assessing motor and non-motor symptoms in patients with Parkinson's disease is the neurological examination, in which the clinician watches the patient perform specific tasks. Clinicians assign points to tasks performed by the patient with the Unified Parkinson's Disease Rating Scale (UPDRS)[1] or MDS-UPDRS (Movement Disorder Society-Sponsored Revision of the Unified PD Rating Scale).[9] With another rating scale, the Hoehn and Yahr scale (HY)[9], the clinical stage of the patient is scored between 0-5. These clinical scales are subjective and may lead to high inter-rater variability between clinicians. Clinical assessments are also based on the progression of symptoms described in patient diaries. The reliability of such reports is limited by subjectivity and patient recall bias.[10]

Accurate diagnosis of PD is vital for prognosis monitoring and treatment.[11] Early and accurate diagnosis of PD can improve the long-term quality of life of people with Parkinson's disease, while misdiagnosis of a patient leads to delays in appropriate treatment. [12, 13] Therefore, there is a need to develop accurate, objective, and continuously recordable tools to assess motor complications in PD.[11] In this context, the use of smart technologies in PD applications has increased in recent years.[14] In particular, smart technologies, such as wearable sensors, are being used to assess the progression of the disease by analyzing the symptoms of Parkinson's patients and even to detect early signs of the onset stage in the early diagnosis of PD.[15] However, no data on the percentage of smart technology use to assess motor symptoms in PD was found in the literature. Popular devices include inertial measurement units (IMUs), force and pressure plates, biopotential sensors, and optical motion capture systems.[16] IMUs usually include accelerometer and gyroscope sensors that can record the data needed to analyze symptoms.[17] Similarly, force sensors in the force plate provide information about the patient's posture and balance.[18] As a complementary method, electroencephalogram (EEG) and electromyogram (EMG) sensors measure neural activity and muscle response, respectively. Optical motion capture systems such as Vicon and Microsoft Kinect analyze body movements in patients' environments. Interconnecting these sensors has also been facilitated by the increasing use of communication protocols such as Zigbee and Bluetooth.

The increasing use of technology in the diagnosis and treatment of PD offers important opportunities to improve the quality of life of patients with Parkinson's disease by providing objective data collection, remote monitoring, and continuous follow-up.[15] Recent studies have focused on various tools that enable objective assessment of motor symptoms such as tremor, rigidity, bradykinesia, postural instability, freezing phenomenon, and speech impairment in Parkinson's disease.[19-21] In this context, the aim of the present review is to describe the main motor symptoms seen in Parkinson's disease patients and to discuss the technologically based methods used in their assessment.

Motor Symptoms in PD

The motor manifestations of the disease consist of four basic symptoms including bradykinesia, resting tremor, rigidity and postural instability, which are also used in the clinical diagnosis of the disease. In the later stages of the disease, postural changes, freezing of gait, disturbances in balance, dystonia, swallowing and speech disorders may also be observed.[22]

Tremor

Tremor is the most common symptom in PD and one of the most difficult symptoms to treat, affecting the extremities, jaw, and tongue.[23] In PD with predominant tremors in the upper extremities, postural and kinetic tremor is usually seen concurrently with resting tremors,[24] which may functionally interfere with task performance, disrupt sleep, and cause difficulties in performing activities of daily living.[25] The type of treatment depends on the cause of the tremor; therefore, an accurate diagnosis of tremor is very important. Various parameters such as the amplitude, subtle changes, activity, or tremor fluctuations of tremors cannot be effectively assessed with current clinical rating scales.[26] In addition, since tremor varies depending on emotions during the day, short-term regular outpatient follow-ups do not accurately reflect the intensity of tremors.[26] Therefore, continuous evaluation of tremors is recommended.[27]

Various sensor systems have been developed to objectively measure tremors in Parkinson's disease. These sensor systems include EMG, accelerometer, gyroscope, goniometer, and optical motion capture systems.[28] These devices enable long-term monitoring of PD, collection of data on tremors, identification of their types, and grading of the severity of PD. However, the major disadvantage of these methods is that they are usually limited to the tremor severity of a single extremity and do not provide a comprehensive, whole-body assessment of postural tremor measurement.[29] While only the contractions in the patient's muscles are measured with EMG signals, the accelerometer measures the linear movement of the patient, the gyroscope measures the body's balance, and the goniometer measures only the range of motion of the joints. By combining these sensors, IMUs offer a new approach. Unlike previous studies, IMUs detect postural tremor.[30]

Among all movement parameters of tremors, wearable devices are used to measure the frequency of tremors.[31] In one study, a wireless motion sensor unit worn on the index finger was used to evaluate patient performance based on tasks similar to activities of daily living.[27] The recordings from the motion sensors showed that the device could be used to classify tremors as postural or kinetic and to measure tremor severity during both standard and non-standard activities. However, it was reported that larger studies are needed to obtain more reliable results because the study was performed using a small sample size.[27]

Wile et al. included 41 patients who wore smart watch devices and whose tremors were monitored within 3-6 minutes.[32] Parameters were recorded with the hands at rest and in the outstretched position. The findings from this study showed that smartwatch PD is highly specific and sensitive in differentiating postural tremors from essential tremors. Thus, smartwatch devices are useful and applicable in both clinical and community settings.[15] However, the disadvantage of this assessment may be that the monitoring time (3-6 minutes) is too short to fully characterize tremors.[32]

Another clinical study used Physilog, an ambulatory analysis method, to assess spatiotemporal parameters of gait, postural sway, physical activity, tremor, and bradykinesia.[15] The study involved 10 PD patients and 10 control subjects who undertook a 45-minute protocol of 17 typical daily activities. As a result, the estimated tremor amplitude was highly correlated with the UPDRS tremor subscore.[33]

In a recent study, Braybrook et al. used the Parkinson KinetiGraph (PKG) system to assess tremors in PD patients and developed a new algorithm to distinguish between resting and postural tremors by calculating the percentage of tremor duration presented between 09:00-18:00.[31] This algorithm not only increased the sensitivity and selectivity of assessing tremor occurrence but also analyzed the relationship between tremor and bradykinesia. In addition, this algorithm has identified a threshold value at which tremor begins to occur. It can be said that technological approaches to measuring tremors can help both researchers understand the neural mechanisms of PD and thus develop new treatments.

Rigidity

Rigidity describes the increased resistance of an extremity or axial body part to passive movement, independent of speed and direction of movement, and is one of the main symptoms seen in PD.[34] Clinically, rigidity is most commonly assessed as part of the motor section of the UPDRS.[35] However, the fact that rigidity assessment is a method used to monitor the course of motor symptoms and the efficacy of treatments in PD necessitates its evaluation with an objective and quantitative method.[35] Elastography, EMG, isokinetic dynamometry, and myotonometry are some of the methods used in the objective evaluation of rigidity.[36] Elastography is the determination of tissue stiffness by examining the images of the tissue to be evaluated with ultrasound and using an objective unit of measurement called Young's Modulus, which expresses the amount of deformation of the muscle under external force.[37] EMG evaluates the electrical fluctuations that occur based on neuromuscular activity as well as muscle responses to standard electrical stimuli and provides information about tonus, elasticity, and rigidity.[38] Isokinetic dynamometry provides information about rigidity by moving any body part at a constant speed and comparing the resistance to movement with normative data.[36] Myotonometry is a method used to measure the biomechanical and viscoelastic properties of soft tissues.[39] It records and evaluates the oscillations that occur in the soft tissue in response to small mechanical effects sent to the soft tissue.[40] In a study using myotonometry as an objective measurement tool to document the effect of deep brain stimulation in alleviating rigidity in Parkinson's patients, it was found that increased rigidity was associated with increased viscoelastic stiffness values. In addition, the use of myotonometry for objective measurement of rigidity was supported.[41]

NeuroFlexor is a clinical method that measures passive movement resistance and its neural, elastic and viscous components.[42] There are studies on its use in patients with Parkinson's disease.[43] In a study, neural and non-neural components of passive movement resistance in the wrist and finger muscles in patients with PD were investigated using the NeuroFlexor method. It was shown that stretch-induced reflex activity, not non-neural resistance, contributes to the rigidity of the wrist muscles in PD. It was concluded that NeuroFlexor is a potentially valuable clinical and research tool for measuring rigidity.[43]

In another study, the Bionics Institute Rigidity Device (BIRD) was used to measure finger rigidity. It was observed that the rigidity measured using the device was moderately compatible with the MDS-UPDRS.[44] The ability of this technique to detect changes resulting from therapeutic intervention may be useful in clinical trials or as a home monitoring tool to track symptom fluctuations. Further studies are needed to improve the robustness and usability of the device and to validate the technique in a larger group. It can be said that these technological approaches to measuring rigidity will contribute to better management of patients' treatment processes with objective and precise measurements by providing remote monitoring and continuous follow-up.

Bradykinesia

Bradykinesia is an important symptom of PD. Bradykinesia is the slowness in the initiation of voluntary movement with a gradual decrease in the speed and amplitude of repetitive actions.[45] Bradykinesia develops early or late in all patients with Parkinson's disease. Patients first develop hypokinesia, then hypokinesia progresses to bradykinesia, and finally akinesia. Akinesia is the advanced level of bradykinesia and means the inability to move. Bradykinesia and akinesia are among the most disabling symptoms in these patients. Since patients have difficulty in initiating and maintaining motor movement, their daily lives are negatively affected. It is important to evaluate bradykinesia and determine the treatment method accordingly. In addition to being equipped with accelerometers and gyroscopes, the touch screens of some smartphones provide an opportunity for bradykinesia assessment because they are very sensitive and capable of sampling many different parameters.[46, 47] In a study, accelerometers were used in the evaluation of bradykinesia and the patient's touching the touch screen at certain intervals, finger taps, and pronation-supination movements were evaluated. When the results were evaluated, it was found that all results correlated with the MDS-UPDRS, which is the gold standard tool for grading motor symptoms in Parkinson's disease patients.[48] In another study, *Leap Motion* (hand tracking device) developed to measure bradykinesia was used. Participants with Parkinson's performed wrist pronation/supination, hand opening/closing, and finger tapping tasks under different conditions. At the end of the assessments, the estimated total bradykinesia scores were found to be in strong agreement with clinical scores. The findings demonstrated that this method can objectively measure bradykinesia in agreement with clinical observation and provide reliable measures over time. Only computer and software are required to perform the assessments and it was concluded that it is suitable for both clinical and home symptom monitoring.[46]

Another study used the *SENSE-PARK* system, which consists of sensors worn by patients. The *SENSE-PARK* system consists of a set of wearable sensors (3 used during the day and 1 at night), a Wii Balance Board, software, and a smartphone application. The sensors monitor the movement of Parkinson's patients during their daily activities by collecting raw motor-related data. This sensor set, together with the algorithms developed during the *SENSE-PARK* project phase, allows the monitoring of gait, hypokinesia, dyskinesia, tremor, and sleep-related parameters. The feasibility and usability of the *SENSE-PARK* system were tested 24/7 for 12 weeks in a study involving 22 Parkinson's patients. This system was found to be very feasible in terms of patient compliance, satisfaction, and ease of use. Patients continued to participate in the program for 16 weeks and most of them requested to continue the program at the end of the study. It was found that wearing such a system increased motivation in patients by providing direct feedback about individual health status.[49] In conclusion, technology-based measurement tools play an important role in the assessment of bradykinesia. These tools can help us better assess the severity of the disease, monitor the efficacy of treatment, and improve patients' quality of daily life.

Postural Control and Mobility Problems

Decreased postural control and mobility, slipping, tripping, falling, and decreased gait in the community are common problems in PD.[50] Accurate assessment of these problems allows clinicians and researchers to monitor disease progression and response to interventions. Traditional three-dimensional video-based motion analysis systems allow comprehensive kinematic and kinetic analysis of movement in PD. These systems require relatively large spaces, are expensive, and require considerable expertise, limiting their use in the clinic and at home. *The Microsoft Kinect* is a camera-based sensor used to directly control computer games through body movement. Kinect tracks the position of the limbs and body without the need for hand controllers or power platforms. The use of a depth sensor also allows *Kinect* to capture three-dimensional motion patterns. It is recognized that this system has the potential to remotely assess movement symptoms in Parkinson's patients.[51] The accuracy of *Kinect* for measuring functional and clinically relevant movements in Parkinson's disease patients has been evaluated. This study examined standing, multidirectional reaching, stepping, and walking in place in PD and handshaking, finger tapping, foot and leg agility, chair lifting, and hand pronation in UPDRS. The results showed that the Kinect system has the potential to be a low-cost, home-based sensor for measuring movement symptoms in people with Parkinson's disease. It was reported to be able to accurately measure the timing and overall spatial characteristics of clinically relevant movements but was not able to provide the same spatial accuracy for smaller movements such as hand wringing or toe-tapping. They concluded that *Kinect* may be useful in detecting relative deterioration in both the timing and size of movements over the same period or in monitoring improvement.[52]

In a study using smartphones with Android operating systems, participants with PD were asked to ''(vocal test) say the sound 'aaah' as long as possible; (posture test) stand upright without assistance for 30 seconds; (gait test) walk twenty steps and return to the starting position; (finger tapping test) tap the screen in a regular rhythm; and (reaction time test) press the button on the screen as soon as the object appeared. Participants then took their smartphones home to perform the five tasks four times a day for one month. The device collected the measurements, and the participants met with the researcher online once a week. In the end, it was determined that Parkinson's symptoms could be measured via smartphone and they found that it had diagnostic potential.[53] In another study, a non-invasive, wearable, and wireless embedded cyber-physical system (CPS) was implemented and tested in real time for both gait analysis and postural instability detection in Parkinson's patients. The CPS takes the form of a wearable sensing system (eight EEG and eight EMG wireless smart electrodes). It is a self-wearable system without the need for patient assistance and electrode placement. The system calculates 57 different indices, estimating the effects of muscles and motor cortex activity during movement. The processing algorithm implemented allows the system to detect critical situations during gait and thus activate corrective feedback movement. In this way, it can be used as an assistive tool even in a home environment, remotely monitoring the medication effect in Parkinson's patients, and collecting data throughout the day. Experimental results clearly show that the system can infer gait differences between Parkinson's patients and healthy individuals, including agonist-antagonist co-activation.[54]

According to these studies, technology-based measurement tools have an important role in the assessment of postural control and mobility. These tools can help us to better assess the severity of the disease, monitor the effectiveness of treatment, and improve patients' quality of daily life.

Freezing Phenomenon

Freezing phenomenon is defined as a motor impairment that causes sudden and temporary pauses in walking. It is one of the important symptoms seen in individuals with PD, especially in the elderly, preventing walking. It is observed in 50% of individuals with PD.[55] The freezing phenomenon usually occurs during the initiation of walking and turning. It also occurs in situations such as crossing a narrow road, door entrances, and individual restrictions where the patient is assigned more than one task.[56]

Traditional subjective assessment methods are the first tests used to evaluate the freezing phenomenon, but these methods do not give us quantitative information. Laboratory-based gait analysis, on the other hand, is one of the quantitative measurement methods and is a system that is applied in a standard gait laboratory or research center, where equipment such as a video recording system, 3D motion capture system, force plate, and EMG are used.[55] In a typical gait laboratory, a 3D dynamic motion capture system is applied to determine the frequency of freezing phenomena, knee and hip angle, stride length, and frequency. In this analysis method, a 3D dynamic model of the patient is prepared by placing several reflective balls on the body and using synchronized cameras. With this method, quantitative results are obtained with a highly accurate human gait analysis in a short time. The laboratory-based gait assessment method is considered a gold standard. However, due to the unpredictable nature of the freezing phenomenon, it is an extremely challenging, lengthy, and costly procedure.[57] It is difficult to use in daily assessment. Therefore, with the development of portable and wireless sensors in recent years, a low-cost and high-reliability ambulatory gait analysis system has been designed to evaluate the freezing phenomenon in PD.[58]

Ambulatory gait analysis includes wearable sensors and portable digital monitoring systems that record various parameters to assess freezing phenomena. Multiple sensors, such as Inertial Measurement Unit (IMU), Force Sensitive Resistance (FSR), and EEG, smartphone-based applications are used to detect episodes of freezing phenomenon.[59]

The IMU consists of specialized sensors for evaluating human gait, such as kinematics and kinetics. An accelerometer records the linear velocity change in 3-dimensional axes. A gyroscope has a freely rotating disc that records angular velocity when the human body is in motion.[55] The sensors can be attached to the lower limbs such as hips, knees, shins, ankles, or feet and can be used to analyze various walking disorders. Many investigators have used a combination of IMU sensors in different parts of the lower limb to assess episodes of freezing phenomena due to its small size, continuous gait signal collection, kinematics, and high reliability compared to electrophysiological (EEG and EMG) based sensors.[58] The disadvantages of IMU sensors are poor precise position calculation due to the accumulation of fundamental errors and insufficient precision of the patient-independent model.[60]

Some researchers have conducted studies on the analysis of gravity response signals using FSR sensors to detect cases of freezing phenomena.[55, 58] FSR is a typical load cell made of semiconductor material whose resistance changes when subjected to force or pressure. Due to its small size and low cost, it can be used embedded in the sole of the foot for ambulatory gait analysis. Many researchers have used FSR designs with different loading capacities in various evaluation parameters for gait analysis of toe lift, heel stride, sensitivity and freezing phenomenon.[61]

The EEG cap is an innovative, ambulatory, non-invasive technique to measure real-time physiological changes in the brain (cerebral cortex, occipital lobe) during pre-freezing phenomenon and freezing phenomenon cases in Parkinson's disease patients. By adopting this approach, some researchers have detected freezing phenomenon cases using different machine learning classifiers in EEG signals.[62]

Some researchers have used a multi-model strategy using physical and physiological sensors (IMU, FSR, EMG, and functional near-infrared sensors) to identify freezing phenomenon events online. The multi-model strategy can reduce the delay in the detection of the freezing phenomenon. This multi-model strategy can provide an in-depth and comprehensive perspective that a single sensor cannot provide. However, the integration of multiple sensors can increase system complexity and cost.[63]

It mainly consists of a triaxial accelerometer, a microcontroller with low power consumption, a bluetooth module, and an 800mA lithium battery that can support the operation of the node for 10 hours. Acceleration measurements are received by a microcontroller at a frequency of 200 Hz via the IIC bus, which then transmits them to the Bluetooth module and transmits the data to the smartphone. This system is one of the technologically based techniques that can be used in the detection of freezing phenomenon attacks in Parkinson's disease. According to research on sensor placement, it has been found that the waist is a better location for sensor placement than other areas such as thighs, legs, feet, and chest. Thanks to its small size, patients will not feel discomfort when they wear this sensor node.[64]

According to the studies, technologically based systems facilitate the detection of frostbite phenomena. These systems may contribute to quantitatively assessing the frostbite phenomenon and improve the quality of daily life of patients.

Speech Disorders

PD is characterized by speech disorders, among many other symptoms. Studies have shown that symptoms related to PD-specific speech disorders may include reduced language flexibility, longer pauses, and monotonous and slow speech. Technology-based methods have been useful in sensitively capturing differences between Parkinson's patients and healthy controls in symptoms such as maximum vocalization time, vocalization coefficient, and facial tremor.[65]

One of the prominent examples of smartphone-related evaluations is the mPower study on PD.[66] This study was conducted with the use of the built-in microphone of the smartphone. The vocal activity recorded by the smartphone is a continuous vocalization process in which participants are instructed to say "Aaaaah" into the microphone and are asked to speak into the microphone at a constant volume for up to 10 seconds. Data from this event include audio files containing measurements from the telephone microphone for the 10-second sustained vocalization and a 5-second countdown before the event.[66] An automated speech assessment is also proposed as part of tests such as posture analysis, gait assessment, finger tapping, and reaction time using commercially available smartphone applications to monitor Parkinson's symptoms in the home environment. With such technology-based assessments, it has become easier to detect Parkinson's symptoms.

Conclusion

This review highlights the importance of technology-based assessments in the diagnosis and management of PD. Compared to traditional methods, technological approaches provide more precise, objective and continuous data tracking, allowing a better understanding of disease progression. In particular, wearable devices, mobile applications and artificial intelligence-based analyses support clinical assessments and increase patients' independence in their daily lives.

The findings show that technology has become an indispensable tool in PH management. However, it should be kept in mind that studies in this field are still in their infancy and more research is needed. Especially in our country, although the prevalence of PD is quite high, the number of studies in this field is limited. This situation requires taking steps to expand the use of technology in the treatment of PD in our country. For this purpose, university-industry collaborations should be established to support the development of new need-oriented technologies. Neurologists, doctors, physical therapists and other healthcare professionals should be informed about technological developments. The technological solutions developed should be integrated into the existing health system and their accessibility should be increased. By participating in international studies, information sharing should be ensured and joint projects should be developed.

In conclusion, the importance of technology in the management of PD cannot be underestimated. In the future, technology-based assessments are expected to develop further and be more widely used in the diagnosis, follow-up and treatment of PD. In particular, it is thought that studies to be conducted in this field in our country will not only improve the quality of life of our patients, but also strengthen the effectiveness of our healthcare system and contribute to our country having a voice in the international arena in this field.

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