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Review Paper

Total Joint Arthroplasty in Patients With Parkinson's Disease: A Review of Recent Literature

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ABSTRACT

Total joint arthroplasty (TJA) of the lower extremities is a successful surgical procedure for end-stage degeneration and is gaining increasing popularity worldwide. Preexisting neurological conditions have been a significant challenge for arthroplasty surgeons for a long time, and they have avoided performing TJA in these patients. Parkinson's disease (PD), an age-related neurodegenerative disorder, is prevalent and associated with a higher likelihood of gait imbalance, falling, and osteoarthritis (OA). The number of patients with PD who experience hip and knee OA is increasing. As a result, some of these individuals may need to undergo total hip or knee arthroplasty (THA/TKA) to alleviate symptoms and improve their function. Patients with PD present a remarkable set of challenges for surgeons owing to increased muscle tone, higher fracture risk, and ligament instability. Currently, limited information is available regarding the outcomes and effectiveness of these procedures in PD patients. The lack of data is a concern because it prevents surgeons from making informed decisions regarding the use of TJA in this patient population. This study aims to summarize the recent literature regarding total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures in patients with PD to help surgeons in this challenging setting and improve their knowledge of potential complications and outcomes in this complex background.

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Introduction

Total joint replacement of the lower extremities, or total joint arthroplasty (TJA), is a commonly performed and successful procedure in patients with end-stage arthritis. TJA replaces the degenerative joint with synthetic components to reconstruct the worn joint surface, relieve pain, and improve patient mobility [1]. With the development of surgical techniques and implant designs, the number of total knee or hip arthroplasties (TKA and THA) performed worldwide is significantly increasing [2]. The American Joint Replacement Registry (AJRR) revealed 2 244 587 hip and knee arthroplasties (primary or revision) were performed between 2012 and 2020. The annual report for 2020-2021 has shown approximately 2.4 million hip and knee surgeries conducted during this period. They also represented an 18.3% increase in the procedures conducted compared with the previous year [3]. Therefore, the number of replacement procedures in young and elderly age groups continues to increase, and surgeons expect favorable results from adequately selected patients.

Apart from factors related to surgical techniques, patient-related circumstances also significantly influence the overall outcomes and surgery-associated complications of TJA surgeries [4, 5]. Preexisting neurological conditions have been a challenge for arthroplasty surgeons for a long time, and they have avoided performing joint replacements in patients with neurological conditions. This could be due to potentially higher associated complications in these patients, such as contractures, paresis, altered muscular tone, and muscular imbalance [6, 7]. However, these procedures have been conducted in patients considered unsuitable for arthroplasty in the past [6, 8, 9]. In recent years, TKA and THA have become significantly more common in patients with neurological disorders, and the available evidence has expanded considerably. These surgeries may be helpful in well-chosen individuals to relieve pain and increase functional capacity. However, TJA has been reported to have higher complication rates and lower implant survival rates [6, 7, 10].

Parkinson's disease (PD) is a neurodegenerative disorder often observed in older individuals. The loss of dopamine and dysfunction of the basal ganglia causes this. PD is associated with a higher risk of falling, gait imbalance, and osteoarthritis (OA) [11, 12]. Therefore, patients with PD may require surgical replacement of the hips or knees. However, studies of TJA in these patients are sparse and limited. Orthopedic surgeons are frequently asked to evaluate the suitability of PD patients for TJA. This study aims to review the recent literature regarding TKA and THA procedures in patients with PD. The results of this study can help surgeons in the challenging setting of TJA in neurologically damaged individuals and increase their understanding of possible complications and outcomes.

TKA

TKA, or total knee replacement, is a practical and cost-efficient surgical option for end-stage knee degeneration. It aims to relieve patients' pain, restore function, and improve their quality of life (QoL) [13-15]. TKA includes resectioning the knee's damaged articular surfaces and resurfacing with prosthetic components (metal and polyethylene) [16, 17]. The longevity of knee prostheses is affected by several factors, but a median of 15-20 years lifespan is expected [16]. TKA has been developed over the past decades since the 1970s, when it was first conducted at a hospital for special surgery [18]. Significant advancements in TKA procedures and implant design have resulted in approximately 85%-90% of patients being satisfied with their knee replacement outcomes [19].

TKA designs have demonstrated excellent clinical outcomes and survival rates in patients with knee OA and rheumatoid arthritis (RA) [20]. Although the primary diagnosis commonly associated with TKA is knee OA (KOA), other possible underlying conditions are inflammatory arthritis, fracture, and malignancy [21, 22]. With the increasing prevalence of knee arthritis due to aging populations, the popularity and global demand for TKA is also increasing [23]. By 2030, it is estimated that there will be an 85% increase in the number of TKAs, amounting to approximately 1.26 million procedures, only in the US [24].

In recent years, the number of TKA cases has increased in elderly patients owing to their longer life expectancy. This means more people with underlying diseases are now candidates for TKA [25]. Although TKA can expand the envelope of the function of damaged knees safely and predictably, surgeons are encouraged to ensure that other noninvasive modalities are discussed with the patient. Unresponsive pain to pharmaceutical therapy in OA patients is the most commonly reported indication for TKA in the literature, and knee replacement should only be considered after exhaustion of available nonsurgical and conservative treatments [17, 26].

Total hip arthroplasty (THA)

THA is one of the most significant successes in modern medicine. Hip replacement was first attempted by Professor Themistocles Glück in Germany in 1891. Subsequently, an interposition arthroplasty was performed. This technique involves placing different tissues between the articulating hip surfaces of the damaged hip [27]. Smith-Petersen invented mold arthroplasty in 1925 using glass; however, it proved insufficient to endure the forces that passed through the hip joint. Subsequently, he collaborated with Philip Wiles to develop the first THA using stainless steel, which was affixed to the bone using bolts and screws [28, 29]. Charnley is the father of modern THA. In principle, his low-friction arthroplasty procedure was similar to modern THA, in which the acetabulum and femoral head are removed and substituted with prosthetic implants [30, 31].

Due to the considerable benefits of THA, the utilization of this technique has been increasing, making it one of the most commonly conducted surgeries in this field. It is usually utilized in the advanced stages of OA-associated joint failure. It is one of the most effective orthopedic surgeries to relieve pain and improve QoL in these patients [32, 33]. Other indications include femoral fractures, RA, avascular necrosis, traumatic damage, bone tumors, and their extent [34, 35]. The long-term survival of THA is affected by various factors, most notably the implant design, surgical technique, patient characteristics (such as good preoperative physical function and balanced muscular strength), and surgeon capability [36]. Recent implant modifications, including larger femoral heads, porous metals, and alternative bearings, have been introduced to reduce early and late TJA failure [37]. Therefore, owing to evolving implant design and surgical techniques, even children and patients with complex conditions previously managed by salvage procedures can benefit from total hip replacement [10]. According to the British National Joint Registry, 97.5% of patients reported improved hip pain and function with low surgical complications [38]. Similar to TKA, THA should also be considered after noninvasive therapeutic modalities, such as physical therapy and pain-reducing drugs, have failed.

TJA in neurological disorders

Besides factors related to implant design and surgical techniques, patient-related factors also significantly influence overall outcomes and surgery-associated complications in TJA surgery [4, 5]. Neurological conditions affecting the hip or knee have been a serious challenge for surgeons performing joint replacement since the day these techniques were utilized. A recent study demonstrated that individuals with a pre-existing neurological diagnosis had higher mortality rates, dislocations, and adverse outcomes after hip replacement surgery than controls [39]. This could be due to the increased risk of associated complications, such as contractures, altered muscular tone, and muscular imbalance (ranging from flaccidity to spasticity) [6, 7], as well as altered anatomy and problems in post-surgery rehabilitation. Abnormal muscle tone can also cause early replacement surgery failure due to dislocation and loosening [10]. Zhang and coworkers documented a relatively high prevalence (9%) of prosthesis dislocation after THA in those with neuromuscular conditions [40]. This rate was reported to be higher (up to 13%) in some other investigations [41]. Patients who undergo TJA are also more susceptible to complications, such as falls and fractures, as well as a prolonged hospital stay [42, 43]. Consequently, surgeons avoid performing TJA in patients with severe neurological diseases due to the perceived complexity and concerns over potential complications, most importantly dislocation and loosening [7, 44]. For instance, the results of a study highlighted that less than 25% of surgeons conducted more than one THA on cerebral palsy (CP) patients within 9 years [45].

Improved medical management of neurological conditions has led to a longer life expectancy in these patients, who are now more likely to develop OA symptoms. Novel techniques and a better understanding of prosthetic joint biomechanics have broadened TJA indications, extending to populations with neurological conditions [10, 45, 46]. Recent investigations have shown that contrary to conventional perceptions, TJA may be associated with favorable outcomes in neurologically disabled patients. A systematic review of 45 studies with 36 251 THA cases indicated that this procedure is helpful in patients with neurological disorders, decreased pain, and improved function. However, a high complication rate has also been noted, with dislocation being the most reported complication (approximately 10.6%) [7]. Ryu et al. investigated dual mobility THA's clinical performance and survivorship in elderly patients with neuromuscular conditions (CP, polio, hemiplegia, and PD). They reported that THA may be a practical treatment for femoral neck fractures in these patients. They observed no difference in the dislocation rate between patients with and without neuromuscular conditions treated with THA [4]. Another study demonstrated that TKA can reduce patients' symptoms and improve functional outcomes, but the complication rate was higher in patients with neurological disorders [6]. It is essential to

mention that TJA procedures, especially for those with neurological deficits, should be conducted by specialists with adequate surgery experience [7].

Altogether, there are limited and conflicting results regarding the effectiveness and efficiency of TJA in patients with neurological disorders. Well-designed systematic reviews and general data would assist orthopedic surgeons in surgical planning for patients with neurological conditions considering TJA. In this review, we summarize recent literature regarding the effectiveness and complications of THA/TKA in patients with PD.

Methods

The latest updates from several English databases and search engines (Google Scholar, ScienceDirect, PubMed, Web of Science, and Scopus) were evaluated since January 2018 to identify potentially related articles. English keywords, as well as Boolean operators "AND" and "OR" in addition to advanced search options, were applied as: (Total knee arthroplasty OR total knee replacement AND Parkinson's disease OR PD) and (total hip arthroplasty OR total hip replacement AND Parkinson's disease OR PD). Articles without English full text, review articles, case reports, and investigations related to other surgeries or neurological conditions were excluded. After eliminating duplicates and irrelevant papers, careful screening of titles and abstracts was conducted. The full-text versions of the remaining publications were read. Any disagreements between the authors were discussed and resolved.

Results

TJA in patients with PD

PD is a degenerative condition caused by loss of dopamine and dysfunction within the basal ganglia. It is the two most common progressive neurodegenerative disorders among older individuals (after Alzheimer's disease), and its prevalence is projected to double by 2030 (8.7-9.3 million) [47, 48]. PD is characterized by the presence of both motor (tremors and stiffness) and non-motor (psychiatric symptoms) symptoms [11, 12]. In PD, gait changes occur, starting with reduced step length and increased double-limb support. In advanced cases, reduced postural control and an elevated risk of falling are observed [49]. Patients with PD are at a high risk of falling, with an estimated 60.5% of patients experiencing at least one episode and 39% experiencing recurrent falls. This increased frequency of falls leads to a higher risk of fractures [50]. These patients also have lower bone density, probably due to poor nutritional status and reduced physical activity [51, 52]. Medical advancements have prolonged life expectancy, and people are now more likely to show severe osteopenia and OA symptoms. These conditions increase the risk of falling and fractures and necessitate TJA [53]. However, studies on joint replacement in patients with PD are limited.

Although PD was historically assumed to be a contraindication for TJA [54, 55], an increasing number of joint replacement surgeries are now being performed in these patients [43, 56]. For example, the incidence of THA in patients with PD increased from 946 to 1655 in the US between 2000 and 2014 [42]. However, the outcomes of TJA in PD patients are not entirely known. While some studies reported high postoperative mortality rates and associated complications, such as fractures, dislocations, and a higher need for revision surgeries [57] in PD patients undergoing TJA, more recent investigations suggest better outcomes and no difference in post-TJA complication rates compared to the population [58]. Wang et al. reported that PD patients showed significantly higher rates of postoperative wound infection (surgical site, superficial and periprosthetic) following TJA procedures [59]. However, this may also be because patients with PD have longer hospital stays, which increases the risk of hospital-acquired infections.

Managing orthopedic issues in patients with PD can be challenging due to several factors. These patients have tight muscles, poor bone quality, tremors, and instability, all of which may worsen the outcomes of TJA [54, 59]. Additionally, PD patients are more prone to falling due to their instability, which can lead to postoperative dislocation and fracture [50, 60]. Since orthopedic surgeons are frequently requested to evaluate patients' suitability for surgical hip or knee replacement, it is crucial to determine the clinical outcomes of TJA in patients with PD [2, 56].

Total hip arthroplasty (THA) in PD patients

Hip fractures are the most common skeletal injuries experienced by patients with PD [54, 61, 62]. A recent study revealed that people with PD have twice the risk of hip fracture than those without this condition [63]. These patients are at higher risk of fractures due to postural instability, reduced bone density, and vitamin D deficiency [64, 65]. Additionally, short- and long-term outcomes of hip fracture, such as post-fracture mortality rate, in patients with PD are worse than those in healthy individuals [66, 67]. Patients with PD also have a higher incidence of degenerative joint disorders and OA due to abnormal stresses around the hip joint. Therefore, these patients may experience severe hip pain and mobility limitations, which may require THA [68, 69].

PD has long been linked with intra- and post-operative challenges in patients after THA. However, now more people with PD are undergoing this procedure due to recent advances in arthroplasty techniques. Although THA improves functional status in PD patients, outcomes are still poorer than those in non-PD patients [57, 70], with higher rates of complications, such as fractures and dislocation [71, 72]. However, patient's hip dislocation rate after THA is controversial [73]. Some studies reported increased dislocation due to muscle rigidity and gait instability [57, 54], while others demonstrated no difference in dislocation rates following THA in patients with PD and populations [76]. The dislocation rate after THA has been reported to range from 0% to 37% in patients with PD [74, 75]. A study evaluated the potential risk factors for early dislocation after THA and reported that PD was significantly associated with short-term dislocation (OR=1.63) [76]. Several strategies have been developed for dislocation management after THA, such as constrained liner, large femoral head, and dual-mobility implants [77-79]. Dual-mobility cups are used in THA cases with a high instability risk, such as patients with neurological deficits. A previous study showed that cementless implants with dual-mobility bearing surfaces could be associated with acceptable long-term outcomes in patients with PD undergoing primary or revision THA. The follow-up time ranged from 4 to 14 years, and Lazennec et al. observed no dislocations at a mean follow-up of 8.3 years. They reported that although all patients experienced an improvement in their pain, disability increased in most patients (68%) at the latest follow-up, which could be due to disease progression in the long term [80]. Another study revealed that dual-mobility hip arthroplasty had good functional results (efficacy and stability) in PD patients with proximal femoral fractures. Cemented components were used in 9 patients, and cementless components were utilized in another 4. They did not report any prosthesis dislocation among patients [75]. Therefore, THA with dual-mobility implants can provide satisfactory outcomes for patients with PD with a low rate of mechanical complications [79]. It seems that the traditional unwillingness to consider THA in patients with PD may be too conservative because the higher long-term mortality rate may be due to the progressive neurological nature of the disease and not surgery, and those with PD report almost the same outcomes as controls [80, 81].

The choice of optimal implant design, surgical technique, and immediate initiation of rehabilitation can improve outcomes (reduce pain and improve function) in patients undergoing THA [75]. Both the direct anterior approach (DAA) and the posterolateral approach (PLA) are safe and effective for femoral and acetabular reconstruction [82]. However, patients with concomitant PD undergoing PLA have a higher risk of postoperative dislocation due to decreased muscle strength. PLA surgery in these patients may cause hip instability and a higher incidence of dislocation [83]. Berliner et al. also indicated that older age, osteoporosis, and PD are significantly associated with an increased risk of early postoperative periprosthetic femoral fractures following DAA in THA [84]. In another study, Yang et al. investigated the efficacy of DAA versus PLA for THA in 209 patients with PD. They demonstrated that the DAA approach resulted in lower dislocation rate and faster recovery of the hip function. However, DAA was associated with more bleeding and prolonged surgery than PLA, possibly due to the special positions and instruments required for lateral femoral prosthesis installation. They found that elderly patients with PD were more prone to hip dislocation after THA due to limb tremors and muscle tonicity. However, neither the DAA nor PLA group showed any significant difference in hip prosthesis dislocation after surgery [85]. Higgins et al. also showed that DAA was superior to PLA in reducing pain and functional recovery time and the risk of postoperative dislocation in patients with PD [86].

Comorbidities, such as PD, are associated with a longer patient stay after THA [87]. Shah et al. reported that Parkinson's did not increase the risk of revision surgeries following THA. However, longer hospital stays and infection-related complications have been observed among patients [88]. Another study reported that PD increases the risk of myocardial infarction (MI) after THA and MI patients had longer stays and higher costs than non-MI patients [89]. Viswanathan et al. analyzed the National Inpatient Sample (NIS) database between 2016 and 2019. They found that 0.2% of patients who underwent primary THA required transfer to a skilled nursing facility (SNF). The study also identified PD as one of the comorbidities with the highest likelihood of patients being transferred to SNF (OR=3.94; P<0.001) [90]. In conclusion, most investigations documented poorer outcomes and increased complication rates in patients with PD after THA compared to the general population. Yang et al. suggested that the occurrence of prosthesis-related complications after THA is more frequent in patients with PD or dementia (P<0.0001). The authors also reported that dislocation was the most common complication [91]. Newman et al. demonstrated that PD can increase the risk of perioperative surgical and medical complications after THA (30% and 54%, respectively). They reported that delirium and UTI were more common in patients with PD [43]. Almost all investigations

Table 1. The characteristics and outcomes of THA in patients with PD

Total Hip Arthroplasty							
Year	**Surgery**	**Study Population**	**Age (y)**	**Study Duration**	**Complications/ Results (in PD Group)**	**Conclusion**	**Ref**
2018	THA	207285 patients	64.5-65.5	Between 2012-2014	• PD was significantly associated with early dislocation (OR=1.63).	THA is a successful procedure with a low overall instability rate.	[77]
2018	THA	52 hips	68.7	Between 2000-2016	• The most common reason for revision after THA was dislocation. • At years 2, 5, and 10, the overall TJA survivor rates were 94.9%, 87.9%, and 72.3%, respectively. • The PD group showed less improvement in functional scores than the control group.	PD is associated with an increased risk of complications after TJA. However, despite the increased risk of complications, patients demonstrate improved functional outcomes.	[57]
2018	THA	19 THA	75.3	Between 2006-2016	• The complication rate was higher in PD patients than in healthy individuals; however, no difference was observed in the rate of complications between trauma and elective surgery.	Both elective and traumatic surgeries can involve THA in patients with PD.	[104]
2018	THA	10519 patients with PD 31679 non-PD patients	73±8.8	Between 2002-2013	• A 52% higher risk of any complication • A 30% higher risk for any surgical complication • A 54% higher risk for any medical complication • Increased chance of postoperative delirium, altered mental status, urinary tract infection, and blood transfusion • Longer lengths of stay • Higher total hospital charges	THA in patients with PD is associated with higher complication rates, longer hospital stays, and higher costs.	[43]
2018	Primary and revision dual mobility THA	59 PD patients	72.5	Between 2002-2012	• 53 of 57 patients achieved good to excellent pain relief after two years, and 40 of 47 patients at the latest follow-up. • The most common complication was cognitive impairment. • One patient experienced hip dislocation, while four patients sustained femoral fractures with a well-fixed stem. • 68% of the patients had an increased disability at their latest follow-up visit.	THA using cementless implants with two mobility-supporting surfaces leads to good long-term results in patients with PD.	[81]
2019	THA	6587 patients with PD 767991 non-PD patients	N/A	Between 2005-2011	• A higher rate of medical complications (pneumonia, urinary tract infection, and sepsis) postoperatively. • A higher rate of complications (dislocation, prosthetic joint infection, and risk of revision) at 90 days and final follow-up.	Patients with PD who undergo THA have an increased risk of postoperative complications, and it is crucial to conduct an individualized risk-benefit analysis and multidisciplinary management.	[60]
2019	THA	24 THA patients (28 hips)	64.67±10.69	Between 2009-2016	• All the clinical outcomes improved. • Poorer functional outcomes in mid- or end-stage PD patients • 16 complications were noted. • The prosthesis survivorship at 60 months for THA was 94.1%.	TJA was associated with excellent pain relief and gain of function in PD patients; however, patients with late-stage PD may suffer from functional loss.	[99]

Total Hip Arthroplasty							
Year	**Surgery**	**Study Population**	**Age (y)**	**Study Duration**	**Complications/ Results (in PD Group)**	**Conclusion**	**Ref**
2019	Primary THA	4003 patients with PD 790 686 non-PD patients	74.5	Between 2000-2014	• Increased length of stay (3.1 vs 2.7 days), total hospital charges ($49,061 vs $45,571), and in-hospital complication rate (14.6% vs 11.7%) • In-hospital mortality did not change.	Higher rates of complications, lengthier hospital stays, and higher expenses are associated with THA in PD patients. However, no increase is found in the in-hospital mortality rate.	[42]
2019	THA	490 patients with PD 490 non-PD patients	73	Between 1999-2012	• Increased revision risk but not with short-term mortality rates • The risk of death was increased at 9 years.	The conventional reluctance to perform THA in patients with PD may be too conservative given that the higher long-term mortality is more likely due to the progressive nature of the disease and not THA itself, and patients with PD show comparable outcomes to controls.	[82]
2020	THA	235 patients with PD 235 non-PD patients	74.34	Between 2009-2011	• A higher rate of overall and postoperative wound infection • No increase in complications or revisions. • Lengthier hospital stay • A greater percentage of the second THA after more than two years	PD patients had similar complication and revision rates as the general population despite longer hospital stays and infection-related complications.	[89]
2020	Dual mobility THA	12 Patients (13 hips)	65	Mean follow-up of 32 months	• No case of prosthesis dislocation • Seven patients returned to pre-fracture activities of daily living with the same disability stage. • Five patients had worsening disability by 1 stage.	Dual mobility THA in patients with PD provides both efficacy and stability with good functional results.	[75]
2020	THA	590 122 THAs	65.12±0.03 for no-prosthesis-related complication group 68.20±0.28 for prosthesis-related complication group	Between 2005-2014	• PD increases the risk of prosthesis-related complications after THA.	A comparatively low incidence of prosthesis-related in-hospital complications has been noted following THA, with complications typically occurring in patients with comorbid conditions such as PD.	[92]
2021	Primary THA	26 PD patients (32 knees)	71	Between 1994-2013	• TKA relieved the pain. • 9–8 days is the average length of hospital stay after surgery. • The most common side effects were flexion contracture and confusion.	The functional outcome is related to PD progression and, therefore, variable.	[94]
2022	DAA THA	989 primary THAs	74.3 (early postoperative fracture) 63.6 (intraoperative fracture)	Between 2009-2015	• The early postoperative fracture group had greater proportions of diagnosed PD (3/10).	PD is associated with an increased risk for early postoperative periprosthetic femoral fracture following the DA approach THA.	[85]
2023	THA	1927 patients with PD 1923 non-PD patients	73.24	Between 2016-2019	• Higher total hospital costs • Longer hospital stay • Greater blood loss anemia, and prosthetic dislocation • No difference in in-hospital mortality rate	PD showed a significant relationship with greater cost of care, longer hospital stay, and higher post-operative complications.	[70]

Total Hip Arthroplasty							
Year	Surgery	Study Population	Age (y)	Study Duration	Complications/ Results (in PD Group)	Conclusion	Ref
2023	DAA and PLA THA	90 patients in the DAA group 119 patients of the PLA group	66.96±4.27 67.71±5.01	Between 2015-2021	• The DAA had a lower incidence of postoperative complications. • A longer operative time in the DAA • More intraoperative blood loss in the DAA • Higher scores of Harris hip score and Western Ontario and McMaster University OA index in the DAA group	The DAA exhibited a lower rate of dislocation than the PLA and had a faster recovery of hip function.	[85]
2023	THA	367890 patients	64.37±10.79 for <2 days group; 69.25±11.99 for >2 days group	Between 2016-2019	• PD (OR=3.57) was associated with a higher likelihood of a length of stay greater than two days.	PD is independently associated with a higher risk of a length of stay greater than two days.	[87]
2024	Primary THA	367890 patients	N/A	Between 2016-2019	• PD increased the risk of MI (OR=1.48). • Patients with MI had increased length of stay, total charges, and generally negative dispositions.	PD increased the risk of MI following THA.	[89]
2024	Primary THA	368431 patients	N/A	Between 2016-2019	• PD (OR=3.94) was associated with a significantly greater need for post-THA transfer to skilled nursing facilities.	0.2% of THA patients required transfer to skilled nursing facilities, and comorbidities like PD increased this risk.	[90]

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Abbreviations: TJA: Total joint arthroplasty; PD: Parkinson's disease; THA: Total hip arthroplasty; TKA: Total knee arthroplasty; DAA: Direct anterior approach; PLA: Posterolateral approach; MI: Myocardial infarction.

reported short-term mortality rates comparable to those of normal populations. Goel et al. revealed that patients suffering from PD who undergo THA require more expensive care, have to stay longer in hospitals, and have higher chances of experiencing post-surgery complications, such as prosthetic dislocation. However, mortality rates were similar between the two groups [70]. In a matched cohort analysis by Kleiner et al., patients with PD undergoing THA experienced higher complication rates (14.6% vs 11.7%) and longer hospital stays (3.1 vs 2.7 days), but no increase in in-hospital mortality [42]. Wojtowicz et al. reported that although THA did not increase the risk of short-term (90 days and one year) mortality in patients with PD, a higher revision risk and long-term mortality rate were documented after nine years [81]. Two previous investigations reported that patients with PD undergoing THA had a higher mortality rate than those without this neurodegenerative disorder [81, 85]. Considering that PD is a progressive disease affecting patients' QoL and life expectancy, it is challenging to speculate what proportion of this increased mortality rate could be attributed to PD progression itself rather than the THA operation. Table 1 summarizes the characteristics and outcomes of THA in patients with PD.

Total knee arthroplasty (TKA) in PD patients

Better medical treatment of patients with PD is expected to increase life expectancy, which will increase the number of patients undergoing TKA [92]. Patients with PD often have knee OA. The knee joint poses difficulties for PD patients in the advanced stages of the disease, causing pain, stiffness, and instability that may require TKA [93]. However, associated orthopedic conditions, such as a high risk of falls and fractures, rigidity, and poor bone quality in PD patients, can make THA challenging for arthroplasty surgeons [53, 72]. Additionally, PD symptoms, such as tremors, shuffling gait, and instability, can increase post-surgical complications and decrease TKA functional outcomes. Moreover, although knee arthroplasty can improve mechanical problems of the knee, reduce pain, and improve function, it cannot prevent the progression of PD [94].

Recent studies show that arthroplasty procedures can provide considerable pain relief, but data on their outcomes and complications in the PD population still needs to be improved [95, 96]. TKA is a successful treatment for reducing pain in weight-bearing joints. How-

Table 2. The characteristics and outcomes of TKA in patients with PD

Total Knee Arthroplasty							
Year	**Surgery**	**Study Population**	**Age (Years), Mean±SD**	**Study Duration**	**Complications/ Results (in PD Group)**	**Conclusion**	**Ref**
2018	Primary TKA	43 knees from 35 patients with PD 50 knees from 41 non-PD patients	72.6	Between 2004-2015	• No significant difference regarding ROM or 12-point Oxford Knee Score • PD is not associated with poorer functional outcomes or increased complications and mortality rate.	PD is not an absolute contraindication to TKA.	[96]
2018	TKA	71 knees	68.5 for the TKA group	Between 2000-2016	• The most common reasons for revision after TKA was periprosthetic infection and periprosthetic fracture. • Overall survivorship of TJA at years 2, 5, and 10 were 94.9%, 87.9%, and 72.3%, respectively. • The improvement in functional score was lower in PD than in the control group.	After TJA, PD is associated with a higher risk of complications; however, despite this increased risk, patients still demonstrate better functional outcomes.	[57]
2018	TKA	15 TKA	75.3	Between 2006-2016	• PD patients have a higher rate of complications than healthy people, but the rates of complications from elective and trauma surgery are the same.	Both elective and traumatic surgeries can involve TKA in patients with PD.	[104]
2019	Primary TKA	7356 patients with PD 73610 non-PD patients	72.0	Between 2000-2012	• Clinically minor increases in length (3.92 vs 3.71 days) and cost ($41,523.52 vs $40,657.00) of hospitalization for TKA in PD patients. • PD patients did not have higher rates of complications or in-hospital deaths.	PD patients may be safely considered for TKA.	[102]
2019	TKA	18 TKA patients (22 knees)	67.89±6.62	Between 2009-2016	• All the clinical outcomes improved. Poorer functional outcomes in mid- or end-stage PD patients • 16 complications were noted. • The prosthesis survivorship at 60 months for TKA was 87.5%.	Although TJA has been associated with significant pain relief and functional improvement in PD patients, loss of function may occur in late-stage PD patients.	[98]
2019	Primary TKA	31979 patients with PD 95 596 non-PD patients	72±8.1	Between 2002-2013	• A 44% higher risk of suffering from any complication • A 45% increased risk for any medical complication • A 9% higher risk for any surgical complication • A 6.5% longer mean lengths of stay • A 3.05% higher mean total hospital charges	After TKA, patients with PD are more likely to experience postoperative complications, longer hospital stays, and higher costs.	[25]
2020	Unilateral TKA with a medial parapatellar approach	13 patients in both groups	75.6±8.13	Between 2006-2018	• No significant difference was observed between 2 groups (PD and non-PD) in terms of knee society score and ROM. • Mean preoperative knee society score and ROM values were significantly lower in high-grade patients compared to low-grade patients. • Mean increase in knee society score and ROM values were significantly higher for high-grade patients.	TKA is a successful treatment of knee OA in PD patients with similar outcomes compared to the general population despite disease severity and progression.	[103]
2021	Primary TKA	46 TKAs in 29 patients with PD 92 TKAs in 58 patients without PD	71.0±5.8	Between 2007-2009	• The mean knee society knee scores improved from 36.8 pre-operatively to 60.0 at the final follow-up. • Outdoor ambulatory patients at the final follow-up included 13 of 20 (65.0 %). • The cumulative mortality rates were 31% (9/29) at the final follow-up. • Survivorship analysis estimated 89.7% chances of survival for ten years in PD patients.	During a follow-up period of at least 10 years, TKA was associated with worse functional outcomes and increased mortality in patients with PD.	[100]

Total Knee Arthroplasty							
Year	Surgery	Study Population	Age (Years), Mean±SD	Study Duration	Complications/ Results (in PD Group)	Conclusion	Ref
2021	Primary unilateral TKA	57 patients with PD 57 non-PD patients	69.3±7.7	Between 2008-2015	• Overall complication rate was 26.3%. • The satisfaction rate was 80.4%. • Higher all-cause mortality rate • Readmissions, length of stay, and discharge to rehabilitation did not differ. • More flexion contractures, lower SF-36 mental and physical component summary at 6 months, and lower Knee Society knee score and Oxford Knee Score at 2 years.	Patients with PD showed significant functional improvements compared to their preoperative status and were very satisfied despite comparatively worse knee function and QoL.	[111]
2022	TKA	3082 patients with PD 555289 non-PD patients	71.44±7.88	Between 2016-2019	• Increased incidence of blood loss anemia • Increased periprosthetic dislocations • Increased periprosthetic mechanical complications • Increased total incurred charges • Increased length of stay	Increased incidence of complications was noted in PD patients undergoing TKA.	[108]
2022	TKA	12 patients with PD 48 non-PD patients	65.4±11.4	Between 2014-2020	• Significant differences in the improvement of QoL measures between PD patients and the control group through EuroQOL5-Dimensions and pain and disability questionnaire at the last follow-up	TKA does not improve the QoL in KOA patients with PD except for a slight improvement in pain-related disability.	[110]
2022	Primary TKA	18082 patients with PD 54244 non-PD patients	N/A	Between 2005-2014	• Greater incidences and odds of medical complications • Greater incidences and odds of implant-related complications • Higher rates and odds of 90-day readmission • Increased costs of care	PD patients undergoing primary TKA had higher incidences of medical and implant-related complications.	[109]
2023	TKA	50 patients with PD	66.91±6.62	Between 2020-2022	• Improved ROM and stability • Higher summary levels for mental and physical components • Reduced pain and stiffness	There is better scoring of PD patients from pre to postoperative state although still with poor motor functional outcomes.	[98]

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Abbreviations: QoL: Quality of life; TJA: Total joint arthroplasty; PD: Parkinson's disease; THA: Total hip arthroplasty; TKA: Total knee arthroplasty; KOA: Knee osteoarthritis.

ever, TKA's efficacy with severe PD remains a concern. Several studies have evaluated functional outcomes following TKA in the PD population, each with contradicting results. Although TKA can provide favorable outcomes for patients with PD, those in the advanced stages may experience worsening motor features. Some studies demonstrated poor functional improvement after joint replacement surgery in PD patients [72, 97]. Noor et al. determined the significance of TKA in patients with PD. They found that TKA improved PD patients' range of motion (ROM) and stability. Surgery also reduces pain and stiffness and improves physical and mental well-being. However, motor functional outcomes remain poor [98]. Rong et al. found that patients with PD who underwent THA or TKA (24 THA and 18 TKA patients) experienced significant improvements in pain and function. The prosthesis survivorship rates for THA and TKA were reported to be 94.1% and 87.5%, respectively (after 60 months). However, those in the mid- or end-stage of the disease have poor functional outcomes [99]. Baek et al. also demonstrated that TKA in patients with PD was associated with weak functional outcomes and increased mortality rates during follow-up. The mortality rates in the Parkinson's and control groups were significantly different (31% and 6.9%, respectively). Additionally, they showed that the functional results of TKA in patients were closely associated with the progression of PD [100]. In another study, Montiel Terrón et al. [93] retrospectively examined 26 patients with PD and OA who underwent TKA. The mean follow-up was 3.5 years (2–9 years). They found that TKA reduced pain and improved ROM in patients with PD, which aligns with previous investigations [57, 96, 101]. They also demonstrated that the rate of motor symptom progression diminishes with advancing PD. While patients in the early stages had a higher chance of functional outcome deterioration, pa-

tients with more progressive PD tended to remain stable after five years. They had a better outcome after surgery [93]. Therefore, it can be concluded that the functional outcomes of PD patients after TKA are correlated with the severity and progression of PD, and doctors should help delay PD progression to optimize TJA outcomes [25, 71, 99].

Most studies have revealed that patients with PD who undergo TKA experience more complications, longer hospital stays, and higher costs than the normal population [26, 102, 103]. Sharma et al. reported that lower extremity TJA (THA and TKA) in patients with PD is associated with higher perioperative complication rates than in those without this neurodegenerative disorder; however, no significant difference was observed in complication rates between elective and trauma surgery settings. They reported a very low local complication rate, with only one local complication in each group (elective and traumatic surgery) [104]. Another study also demonstrated that PD is associated with an increased risk of complications following TJA (52 hips and 71 knees), mostly periprosthetic infection, fracture, and dislocation [57]. The incidence of periprosthetic joint infection has been documented in the literature to be 0.92% and 0.88% after TKA and THA, respectively [105]. Additionally, it has been reported that the dislocation rate following THA ranges from 1% to 3%, while the periprosthetic fracture rate is 0.6% [106, 107]. However, these complications have been reported to be higher with PD payments. Rondon et al. reported that 23.6% of PD patients required revision surgery in an average follow-up of 5.3 years. The survivorship of knee implants at years 5 and 10 was 89.8% and 66.2%, respectively, and hip implant survivorship was 85.3% and 78.7%, respectively. TJA improved functional outcomes in PD patients but not individuals without PD [57]. In a retrospective study of patients who underwent TKA with and without PD, Cheppalli et al. reported an advanced risk of periprosthetic mechanical problems and an increased cost of care patients with PD [108]. Marchand et al. also demonstrated that PD patients undergoing primary TKA have more medical (4.21 vs 1.24%; OR=3.50) and implant-related (5.09 vs 3.15%; OR=1.64) complications, higher readmission rates, and costs compared with controls [109]. Another study indicated that PD increased hospitalization time (6.5%), charge (3.05%), and perioperative complications after TKA. Since most of these complications can be controlled, multi-specialty patient optimization is required [25]. Altogether, these results suggest that patients with PD can benefit from perioperative consultation with a neurological specialist to reduce complications and improve outcomes after TJA.

While the literature reports high complication rates in PD patients undergoing TKA, some investigations demonstrated no significant increase in the studied populations' complications. Wong et al. compared the outcomes of TKA in those with PD and those without PD. They suggested that PD is not a contraindication for TKA; however, PD patients show outcomes equivalent to those of the general population. No mortalities occurred during the follow-up period. They reported that PD patients exhibited functional outcomes and complications comparable to controls [96]. Kleiner et al. found that patients with PD who underwent TKA experienced slightly longer hospitalizations and higher costs. However, no increase was found in complications or mortality rates, suggesting that patients with PD can be safely considered for TKA [102]. Another study reported that TKA is a successful surgical option for KOA in patients with PD, with comparable results to the population despite the severity and progression of PD. They reported that preoperative function was low in patients with high PD severity, while postoperative function was comparable to that in the severe PD group [101]. Surgery is a suggested treatment for end-stage knee OA with satisfactory results, which may improve patients' QoL. Studies have reported that TKA can improve the knee function in patients with PD. However, the positive impact of the procedure was less than that in non-PD patients [57]. In 2022, Zong et al. found that TKA did not improve QoL outcomes in patients with KOA and PD, except for a subtle reduction in pain-related disability. Although the two groups had similar preoperative QoL outcomes, those with PD had worse QoL on all three measures (EuroQol five-dimension [EQ-5D], pain and disability questionnaire [PDQ], and patient health questionnaire-9 [PHQ-9]) at the last follow-up [110]. Another study published in 2021 reported that although individuals with PD have diminished knee function and poorer QoL after TKA, they still experience significant functional improvements and high satisfaction compared to their preoperative situation. The complication and mortality rates were higher in PD patients than in the control group (26.3% vs 10.5% and 15.8% vs 5.3%, respectively) [111].

Although not comparable with control groups, some studies demonstrated low complication rates and promising functional outcomes in patients with PD compared to their condition before the surgery. This led to their satisfaction with the outcomes. These results emphasize that TKA remains a potential surgical option for OA in this expanding patient population. However, evaluating the long-term consequences of TKA in these studies was difficult due to the short follow-up period. Therefore, according to the available literature and controversial re-

sults, the necessity of TJA in the population of patients with PD should be evaluated, carefully depending on individual needs and conditions. In conclusion, in appropriately selected patients, PD severity and progression do not dramatically affect the outcomes of TJA. Although the effectiveness of TJA in individuals with PD remains a concern, we believe that PD should not prevent surgeons from performing TKA. Table 2 summarizes the characteristics and outcomes of TKA in patients with PD.

Conclusion

Joint arthroplasty is a safe and effective surgical procedure for treating end-stage OA. It can reduce pain, improve ROM, and enhance mobility and function in patients who do not respond to conservative intervention. PD patients have been found to have a higher complication rate after TJA, and the indication of TJA in patients with PD is a matter of debate due to the limited availability of consistent outcomes in existing publications. The available literature consists of a small number of retrospective patient cases, with significant variation in the disease stage and lack of adequate monitoring during postoperative follow-up, all contributing to the absence of a consensus. It is challenging to describe a straightforward approach for patients since PD is a complex condition with non-linear progression rates and considering multiple factors, such as sex, time since diagnosis, occurrence of falls, and response to medical treatment. Consequently, it is difficult to provide recommendations that meet realistic expectations. Surgery is not recommended until pain intensity and features careful analysis and failure of conservative steps. According to the information presented in the existing literature, TKA and THA can be considered safe procedures for patients with PD in terms of mortality rate and short-term complications. However, most studies have reported increased complications (mostly fracture and dislocation), prolonged hospital stays, and escalated costs in these patients.

Ethical Considerations

Compliance with ethical guidelines

This article is a review with no human or animal sample.

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Authors' contributions

Conceptualization: Alireza Ghanbari, Abolfazl Bagherifard, and Babak Roshanravan; Collection, assembly, and data extraction: Hooman Yahyazadeh, Karo Khosravi, Amir Azimi, Reza Ahmadi, and Babak Roshanravan; Writing the original draft: Alireza Ghanbari, Karo Khosravi, Amir Azimi, Reza Ahmadi, and Babak Roshanravan; Review and editing: Alireza Ghanbari, Hooman Yahyazadeh, Abolfazl Bagherifard, Karo Khosravi, Amir Azimi, Reza Ahmadi, and Babak Roshanravan; Supervision: Abolfazl Bagherifard, and Babak Roshanravan.

Conflict of interest

The authors declared no conflict of interest.

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