

# The impact of Parkinson's disease on results of primary total knee arthroplasty

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- Parkinson's disease (PD) is a common neurodegenerative disorder.
- When patients with PD undergo total knee arthroplasty (TKA) for knee osteoarthritis, poorer knee function and poorer quality of life are obtained than in matched cohorts (MCs). However, the degree of patient satisfaction is usually high.
- The mean length of stay is 6.5% longer in patients with PD than in MCs.
- Compared with MCs, patients with PD undergoing TKA have a 44% higher risk of complications.
- In patients with PD, the overall complication rate is 26.3% compared with 10.5% in MCs; the periprosthetic joint infection rate is 6.5% in patients with PD vs 1.7% in MCs; and the periprosthetic fracture rate is 2.1% in patients with PD vs 1.7% in MCs.
- The 90-day readmission rate is 16.29% in patients with PD vs 12.66% in MCs. More flexion contractures occur in patients with PD.
- The rate of medical complications is 4.21% in patients with PD vs 1.24% in MCs, and the rate of implant-related complications is 5.09% in patients with PD vs 3.15% in MCs. At 5.3 years' mean follow-up, the need for revision surgery is 23.6%.
- The 10-year implant survival, taking revision of any of the components as an endpoint, is 89.7% in patients with PD vs 98.3% in MCs.

## Keywords

- ▶ Parkinson's disease
- ▶ total knee arthroplasty
- ▶ results

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## Introduction

Parkinson's disease (PD) is one of the most common and complex neurological disorders, primarily affecting older adults (1). It is characterised by motor symptoms (rigidity, bradykinesia, tremor, and postural instability) and a number of non-motor features in the form of autonomic, cognitive, psychiatric, and behavioural dysfunctions (2).

With proper medical treatment, patients with PD can live up to 10 years after being diagnosed with the disease. These patients can also develop musculoskeletal diseases such as osteoarthritis (OA) of the knee (3).

Total knee arthroplasty (TKA) is a technique that offers excellent results in patients with degenerative OA of the knee (4, 5, 6). However, there is very little information on the potential benefit of TKA in patients with PD and knee OA (7).

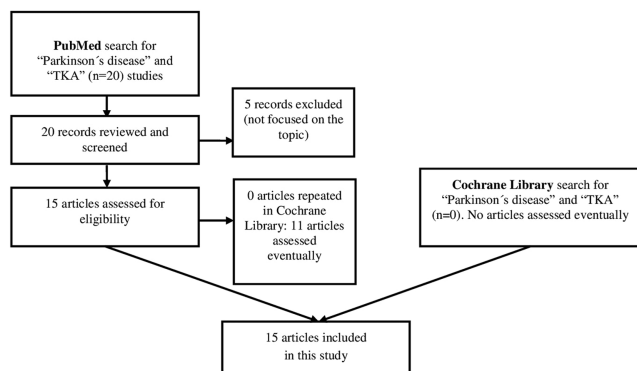
The purpose of this article is to perform a narrative review of the literature to understand the impact of PD on the results of primary TKA. Once these predictors are known, we should attempt to avoid them whenever

possible to minimise the risk of complications after primary TKA implantation.

A PubMed (MEDLINE) and Cochrane Library search of studies related to PD in TKA was analysed. The keywords used were 'Parkinson's disease AND TKA'. The main inclusion criteria were that the articles were focused on PD in TKA. Studies not focused on such keywords were excluded. The searches were from the beginning of the search engines until 18 August 2022. The number of papers found was 20, of which 15 were finally chosen (Fig. 1).

## Incidence

According to Park *et al.*, approximately 80 000 patients with PD were living in Korea in 2019, and 23.9 new cases per 100 000 population were diagnosed each year. They also noted that with the increasing ageing of the population in recent years, the prevalence of PD had also gradually increased (8).



**Figure 1** A flow chart of our search strategy regarding the impact of Parkinson’s disease (PD) on primary total knee arthroplasty (TKA). The main inclusion criteria were that the articles were focused on PD and TKA. Studies not focused on such keywords were excluded.

According to Fox and Brotchie, PD is a common neurodegenerative disorder. Age is the most important risk factor, with prevalence rising from 1% in the 45–54 age group to 2–4% in the 85+ age group. The authors also note that with the increase in the ageing population, we can predict a ‘PD pandemic’ in the future and that its prevalence will double in the next 20 years. Therefore, there is an urgent need to find effective treatments to reduce the burden of the disease (9).

### The impact of PD on results of primary TKA

Several articles have been published on the impact of PD on primary TKA outcomes (functional results, pain relief, and quality of life (QoL)).

#### Functional outcomes

In a study published in 2013 by Tinning *et al.*, the functional capacity did not improve after TKA (10). In this case–control study, the authors evaluated the short-term clinical outcomes of primary TKA in a group of patients with PD. Thirty-two TKAs were implanted in patients with PD and 33 TKAs in an age-matched control group (mean age: 73 years). Preoperatively, there were no differences between the two groups in terms of Knee Society Score (KSS), pain score (VAS—visual analogue scale), Knee Society Function Score (KSFS), or range of movement (ROM). The KSS score improved in both groups postoperatively, with no significant difference between groups ( $P=0.707$ ). Therefore, there was functional improvement after TKA in the PD group.

In 2021, Montiel Terrón *et al.* evaluated the functional outcomes achieved after TKA in patients with PD. They

**Table 1** Hoehn and Yahr scale for Parkinson’s disease (13).

Stage	Features
1	Unilateral involvement only
2	Bilateral involvement without impairment of balance
3	Mild-to-moderate bilateral disease, some postural instability, physically independent
4	Severe disability, still able to walk or stand unassisted
5	Wheelchair bound or bedridden unless aided

performed a retrospective review of 26 patients (32 knees) with PD and OA who had undergone TKA (11). The patients’ functional status was assessed with the KSFS and the KSS. PD stage was classified using the Hoehn and Yahr scale (Table 1). The mean follow-up was 3.5 years (range: 2–9). The mean age of the patients was 71 years (range: 61–83), with a mean time since PD diagnosis of 11.8 years (range: 4–24). The PD severity on the Hoehn and Yahr scale was 1.5 points before surgery and 2 points after surgery. Function improved from 32 (range: 20–45) to 71 (range: 50–81) and from 34 (range: 28–52) to 59 (range: 25–76) on the KSS and KSFS, respectively. Functional outcome was related to disease progression and therefore variable (11).

It has been stated by Rong *et al.* that patients with late-stage PD can have functional loss after TKA (12). Rong *et al.* retrospectively analysed the clinical outcomes of 18 patients with TKA (22 knees). PD stage was assessed using the Hoehn and Yahr scale (13). Prosthesis survival was estimated with revision for any reason as the endpoint. All clinical outcomes were significantly improved ( $P < 0.05$ ). The subgroup analysis showed poorer functional outcomes in patients with mid- or late-stage PD. Prosthesis survival at 60 months for TKA was 91.6%, 94.1%, and 87.5%, respectively. Patients with PD who underwent TKA had excellent gain of function. However, patients in the advanced stage of PD had functional loss. PD subjects at Hoehn and Yahr stage I or II could keep balance, remain independent, and be functional free. However, at stage III, subjects would develop postural instability with mild functional restriction. At stage IV or stage V, these symptoms deteriorate, and severe disability could be found. Based on this phenomenon, Rong *et al.* enrolled subjects at stage I or II into the functional free group (group I). Subjects at stage III to V were enrolled in the functional restriction group (group II). The clinical results were compared between them. Of the subject in TKA group, the KSFS ( $P < 0.01$ ), the Short Form (12) Health Survey scale (SF-12) physical component summary (PCS) ( $P < 0.01$ ) and mental component summary (MCS) ( $P < 0.01$ ), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain ( $P=0.03$ ) and function score ( $P < 0.01$ ) were significantly higher in group II. Moreover, comparisons of the final clinical data with preoperative data were carried out in each group. Significant differences of all the data were found in group

I. However, in group II, there were no differences in KSFS ( $P=0.50$ ). The SF-12, PCS ( $P=0.10$ ), MCS ( $P=0.26$ ), and WOMAC function score ( $P=0.74$ ) were not statistically different as well. The efficacy of TKA in patients with severe PD remains a concern. To optimise and stabilise the functional outcomes of a TKA, the medical team should attempt to slow the progression of PD (12).

Goh *et al.* have claimed that although patients with PD have relatively poorer knee function and QoL, they experience functional gains, and high satisfaction is achieved (14). In a comparative level 3 evidence study published in 2021, the rates of complications, mortality, and revision, as well as patient-reported outcomes and the satisfaction of patients with PD, were compared with those of a control group after unilateral primary TKA implantation (14). Patients with PD who underwent TKA were identified and matched 1:1 with a control group using propensity scores adjusting for age, sex, BMI, Charlson comorbidity index (CCI), baseline ROM, KSS, KSFS, Oxford Knee Score (OKS), and 36-item SF-12 MCS and PCS. Functional outcomes and patient satisfaction were assessed at 6 months and 2 years. Complications, survival, and all-cause mortality were analysed. In total, 114 patients were included. The majority of patients with PD had Hoehn and Yahr stage 1 or 2 disease. There were no differences in transfusions, hospital length of stay (LOS), discharge to rehabilitation, or readmissions. Patients with PD had more flexion contractures, poorer KSFS and OKS at 2 years, and a poorer 36-item SF-12 PCS at 6 months. The KSFS mean score in PD was 39.1, while in the control group the mean score was 34.8 ( $P=0.363$ ). The OKS mean score in PD was 20.5, while in the control group the mean score was 19.9 ( $P=0.747$ ). Some 80.4% of the patients with PD were satisfied compared with 85.5% of the controls ( $P=0.476$ ). During a follow-up of 8.5 years, one TKA was revised in each group. Although the patients with PD had relatively poorer knee function and QoL than in the control group, these patients experienced significant functional gains compared with their preoperative status. In addition, their satisfaction with the outcome of TKA was high (14).

Wong *et al.* have reported that PD patients had no poorer functional outcomes than the control group patients (7). This study compared the outcomes of TKA in patients with PD (43 knees and 35 patients) and without PD (50 knees and 41 patients). The indication for TKA implantation was knee OA. In both groups, the age and sex of the patients were similar. The TKAs were implanted by two surgeons in a private tertiary hospital. Student's unpaired *t*-test was used to evaluate the differences between the ROM and the 12-point OKS preoperatively and at 1 year. The minimal clinically important difference for OKS at 1-year follow-up, defined as an amelioration

of  $\geq 6$ , was also evaluated. In the PD group, the mean ROM improvement was  $14^\circ$  ( $100^\circ$  preoperatively to  $114^\circ$  at 12 months), whereas in the control group it was  $12^\circ$  ( $102^\circ$ – $114^\circ$ , respectively). Mean OKS improvement was 15 in the PD group (23 preoperatively and 38 at 12 months), compared with 17 in the control group (23 and 40, respectively). No significant differences were observed between the two groups for either ROM ( $P=0.96$ ) or OKS ( $P=0.45$ ). The conclusion of this study was that PD had no poorer functional outcomes than the control group. Therefore, Wong *et al.* stated that PD disease was not an absolute contraindication for TKA (7). We are of the opinion that PD should not be an absolute contraindication for TKA implantation, but it should also be noted that most authors have found greater complications and poorer long-term outcome rates than in matched cohorts (MCs).

#### *Pain and quality of life*

In the comparative study of Tinning *et al.*, TKA provided excellent pain relief in patients with PD (10). In 2021, Montiel Terrón *et al.* found that pain on the VAS improved from 8 points preoperatively to 5 points at 1-year follow-up. TKA successfully relieved pain in patients with PD (11).

In 2022, Zhong *et al.* stated that the number of patients with PD undergoing TKA is increasing (15). They conducted a study to attempt to characterise the QoL outcomes in patients with PD and knee OA following TKA. Patients with PD and knee OA who underwent TKA were included. Patients were matched to controls with knee OA alone by age, sex, basic social background information, and KSS. The primary measure was to assess the QoL by the absolute changes in the EuroQoL5-Dimensions (EQ-5D), the Pain and Disability Questionnaire (PDQ), and the Patient Health Questionnaire-9 (PHQ-9) at the end of follow-up. Secondary measures were changes in QoL that exceeded the minimum clinically important difference. Data on health status and QoL were collected for all patients. Simple and multivariate regression analysis was used to assess the impact of PD on their QoL. Twelve patients with PD and knee OA were compared with 48 controls. At the end of follow-up, patients in the control group experienced a significant improvement in QoL for all three measures: the EQ-5D index (0.545–0.717,  $P < 0.01$ ), the PDQ (81.1–52.3,  $P < 0.01$ ), and the PHQ-9 (8.22–5.91,  $P < 0.01$ ). However, in the patients with PD, only the PDQ (91–81.4,  $P=0.03$ ) improved slightly. At the end of the follow-up, there were significant differences in QoL improvement between the patients with PD and the control patients with respect to EQ-5D (0.531 vs 0.717,  $P < 0.01$ ) and PDQ (81.4 vs 52.3,  $P < 0.01$ ). In patients with knee OA and PD, TKA did not provide any benefit over QoL beyond a slight improvement in pain-related disability (15).

## The impact of age of onset and disease duration on the clinical picture in patients who had the disease for 20 years or more

In a study published in 2015 by Cilia *et al.*, an attempt was made to gain a better understanding of PD 20 years after onset. To this end, the impact of age of onset and disease duration on the clinical picture was investigated in patients who had the disease for 20 years or more (16). Possible predictors of outcome were also investigated. In that study, 320 patients with disease duration  $\geq 20$  years ( $n=401$ ) were stratified according to disease duration (20–22, 23–25, and  $\geq 26$  years) and age of onset (cutoff, 50 years). Patients with a disease duration of 20–22 years were prospectively assessed for a median of 45 months (interquartile range: 23–89) for the occurrence of fracture, percutaneous endoscopic gastrostomy, institutionalisation, confinement to a wheelchair or bed, and death. Older age at onset and longer duration of illness were found to be independently associated with a higher prevalence of major motor and non-motor illness milestones (although no interaction was observed). The most frequent outcomes were death ( $n=92$ ), confinement to wheelchair or bed ( $n=67$ ), and fracture ( $n=52$ ). Mortality was associated with male sex, advanced age, dysphagia, orthostatic hypotension, postural instability, fractures, and institutionalisation. Fracture was associated with postural instability. Predictors of permanent confinement to a wheelchair or bed were advanced age, postural instability, and institutionalisation. Comorbid dementia at the 20-year assessment did not predict any of the outcomes. Cilia *et al.* concluded that age at onset and disease duration were independent determinants of clinical PD features beyond 20 years of the disease. Non-motor symptoms were more dependent on age of onset than on disease duration. Non-levodopa-responsive axial symptoms were the main predictors of all relevant outcomes (16).

## Length of stay and cost of hospitalisation

In a level 3 prognostic type of evidence study, published in 2019 by Kleiner *et al.*, the MC analysis demonstrated statistically significant, but clinically minor, increases in length of stay (LOS) and cost of hospitalisation for TKA in patients with PD (17). The complication rate and hospital mortality rate were not higher in patients with PD, suggesting that this group could be safely considered for TKA. Kleiner *et al.* stated that a higher complication rate in patients with PD after TKA had been found. However, this difference had not previously been studied on a

national scale. Therefore, using a national database, they tried to discover whether patients with PD had higher costs, complications, mortality, and LOS after TKA. They evaluated the Healthcare Cost and Utilization Project Nationwide Inpatient Sample from the years 2000 to 2012. Patients with PD were matched 1:10 with control patients without PD for age, sex, CCI, and year of admission, using a propensity score matching procedure. Univariable and multivariable logistic regression were used to determine the relationship between PD and surgical outcomes in the MC. Before matching, TKA patients with PD were significantly older ( $P < 0.0001$ ) and were more frequently male ( $P < 0.0001$ ) and had a higher CCI ( $P=0.3058$ ). In the MC, PD was associated with a significant increase in LOS (3.92 vs 3.71 days,  $P < 0.0001$ ) and total hospital costs (\$41 523.52 vs \$40 657,  $P=0.0037$ ). There was no significant difference in the in-hospital complication rate (8.28% vs 8.04%,  $P=0.4297$ ) or the in-hospital mortality (0.164% vs 0.150%,  $P=0.8465$ ) between patients with PD and matched patients without PD. An MC analysis demonstrated a statistically significant, but clinically minor, increase in LOS and hospitalisation costs for TKA in patients with PD (17).

A therapeutic level 3 evidence study published in 2019 by Newman *et al.* evaluated LOS and total hospital costs. The Nationwide Inpatient Sample was used to identify patients with PD who underwent TKA. To control for potential confounders, PD TKA and non-PD TKA patients were propensity score matched (1:3) based on age, sex, ethnicity, CCI, and insurance type. A total of 31 979 PD and 95 596 non-PD TKA patients were included. Compared with the MC, patients with PD had a 6.5% (95% CI: 5.46–7.54) longer mean LOS and 3.05% (95% CI: 1.99–4.11) higher mean total hospital costs (19). In the study of Montiel Terrón *et al.*, the mean postoperative hospital stay was 9.8 days (range: 5–21) (11).

Baek *et al.* have affirmed that TKAs in patients with PD gave poorer functional outcomes and higher mortality over a minimum 10-year follow-up period (18). In 2021, Baek *et al.* compared functional outcomes, activity levels, mortality, implant survival rates, and complications of TKA in patients with PD with those of patients in a control group during a minimum follow-up of 10 years (18). They analysed 46 TKAs in 29 patients with PD (PD group) and 58 patients without PD (control group) in a 2:1 ratio using propensity score matching. The mean KSS in the PD and control groups improved from 36.8 and 37.1 points preoperatively to 60 and 80.7 points at final follow-up, respectively ( $P < 0.05$ ). Outdoor ambulatory patients at the final follow-up included 13 of 20 (65%) in the PD group and 51 of 54 (94.4%) in the control group ( $P < 0.05$ ). It was observed that TKA in patients with PD had poorer functional outcomes over a minimum 10-year follow-up period. Therefore, the necessity of the procedure

**Table 2** Publications on the impact of Parkinson’s disease (PD) on results of primary total knee arthroplasty (TKA).

Parameter	Results	References
Pain relief	Satisfactory pain relief	Tinning <i>et al.</i> (10), Montiel Terrón <i>et al.</i> (11), Zhong <i>et al.</i> (15)
Functional ability	Functional ability did not improve	Tinning <i>et al.</i> (10), Baek <i>et al.</i> (18)
Functional loss	Functional loss was found in patients at last-stage PD	Rong <i>et al.</i> (12)
Knee function	Knee function was poorer in patients with PD than in matched cohorts (MCs)	Goh <i>et al.</i> (14)
Length of stay (LOS)	LOS was increased compared with MCs Mean LOS is 6.5% longer in patients with PD than in MCs	Kleiner <i>et al.</i> (17)
Cost of hospitalisation	Cost of hospitalisation was increased compared with MCs \$17 105.43 in patients with PD vs \$15 252.34 in MCs Average total hospital charges 3.05% higher in patients with PD than in MCs	Newman <i>et al.</i> (19) Kleiner <i>et al.</i> (17) Marchand <i>et al.</i> (21)
Quality of life (QoL)	Poorer QoL than MCs	Newman <i>et al.</i> (19)
Patient satisfaction	High patient satisfaction	Goh <i>et al.</i> (14), Zhong <i>et al.</i> (15)
Mortality	Higher mortality than in MCs  Some 34.7% of patients with PD and 59.7% of MCs survived to 10 years of follow-up Some 31% of the mortality rates following TKA in individuals with PD were higher than 6.9% of the individuals in MCs at a minimum follow-up period of 10 years All-cause mortality was higher in the PD patients than in MCs (15.8% vs 5.3%)	Goh <i>et al.</i> (14) Jamsem <i>et al.</i> (22), Rondon <i>et al.</i> (20), Baek <i>et al.</i> (18) Rondon <i>et al.</i> (20) Baek <i>et al.</i> (18) Goh <i>et al.</i> (14)

should be carefully considered according to the needs and conditions of each patient (18). Table 2 summarises the publications regarding the impact of PD on primary TKA results.

### Early neurological consultation is essential

It has been published that early neurological consultation for patients with PD can significantly reduce LOS and improve early outcomes after TKA implantation (3). Considering that in 2008 the impact of PD on TKA outcomes was not well known, Metha *et al.* evaluated whether early medical management of PD would affect TKA outcomes (3). To do so, they retrospectively analysed 34 patients (39 knees) with PD who underwent TKA surgery. Patients received either an immediate preoperative/postoperative neurological consultation ( $n=13$ ) or a delayed consultation ( $n=21$ ). Clinical outcomes and functional recovery were assessed with the Knee Society scoring system and the Unified Parkinson’s Disease Rating Scale. There were no significant preoperative differences between the two study groups. The mean follow-up was 36 months. Compared with the delayed consultation group, the preoperative/immediate postoperative consultation group had a shorter LOS (2.5 days) after surgery and a 19-point greater improvement in Knee Society Pain and Function scores. In addition, a statistically significant improvement in Unified Parkinson’s Disease Rating Scale severity scores was observed in the preoperative/immediate consultation group, but not in the delayed consultation group. Therefore, the conclusion was that early neurological consultation for patients with PD can significantly decrease LOS and improve early TKA outcomes (3).

### Postoperative complications of primary TKA in patients with PD

Several articles have been published on the complications of patients with PD undergoing primary TKA surgery. In 2013, Tinning *et al.* expressed that TKA provided an acceptable complication profile (10). The most frequent perioperative complications in the study of Martín Terrón *et al.* were confusion and flexion contracture (11). The study of Kleiner *et al.* demonstrated that the complication rate was not higher in patients with PD, suggesting that this group could be safely considered for TKA (17). The overall complication rate reported by Goh *et al.* was 26.3% in the PD group and 10.5% in the control group ( $P=0.030$ ) (14).

Wong *et al.* have claimed that PD patients have no more complications than the control group patients (7). In a comparative study, the PD group of patients had no more complications than the control group patients (7). There were no deaths during the follow-up period nor were there significant differences in complication rates between the two groups ( $P=0.41$ ). The conclusion of this study was that PD had no more complications than the control group.

Newman *et al.* found that patients with PD had a 44% increased risk of any complication (odds ratio (OR): 1.44; 95% CI: 1.35–1.54), a 45% increased risk of any medical complication (OR: 1.45; 95% CI: 1.36–1.55), and a 9% increased risk of any surgical complication (OR: 1.09; 95% CI: 0.84–1.41). Newman *et al.* stated that since many of these complications are preventable, a team-based multispecialty patient optimisation is needed (19).

#### Periprosthetic joint infection

As revealed in 2018 by Rondon *et al.*, patients with PD have an increased risk of complications after TKA,

particularly periprosthetic joint infection (PJI) (20). The authors stated that, despite this increased risk of complications, patients with PD can achieve good functional outcomes but not as good as patients without PD; also, that patients with PD should receive appropriate counselling before undergoing TKA. Gait instability and muscle stiffness, known features of PD, put these patients at particular risk for complications after TKA. Rondon *et al.* conducted a study evaluating the outcomes of TKA in patients with PD. They performed a single-institution retrospective review of 71 TKAs. A control cohort was matched 2:1 based on age, BMI, the joint, and comorbidities. After a mean follow-up of 5.3 years, 23.6% of patients required revision surgery. The most common reason for revision TKA was PJI (20).

In 2021, Baek *et al.* observed PJIs in three patients in the PD group (3/46, 6.5%) and in one patient in the control group (1/58, 1.7%). All four PJIs were treated by two-stage revision arthroplasty (18).

*Medical and implant-related complications*

In 2020, a study by Marchand *et al.* sought to determine whether patients with PD who undergo primary TKA have an increase in medical complications and implant-related complications (21). A query was conducted using an administrative claims database. The study group consisted of 72 326 patients. Patients with PD undergoing primary TKA numbered 18 082. The control group consisted of patients without PD who underwent primary TKA (*n* = 54 244). Pearson’s chi-squared tests, logistic regression analyses, and Welch’s *t*-tests were used to test for significance between the cohorts. Primary TKA patients with PD were observed to have a higher incidence and likelihood of medical complications (4.21% vs 1.24%; OR: 3.50; 95% CI: 3.15–3.89; *P* < 0.0001) and implant-related complications (5.09% vs 3.15%; OR: 1.64; 95% CI: 1.511.79; *P* < 0.0001) than in the control group (21).

*90-day readmission rates*

Marchand *et al.* also found that the 90-day readmission rates and odds of readmission were higher (16.29% vs 12.66%; OR: 1.34, *P* < 0.0001) in patients with PD (21).

*Periprosthetic fracture*

In the study of Baek *et al.*, a periprosthetic fracture of the femoral diaphysis was observed in one patient in each group (1/46 (2.1%) and 1/58 (1.7%), respectively), which was treated with plate and screw fixations (8). The different rate of periprosthetic fracture of the femoral diaphysis between patients with PD (2.1%) and patients in the control group (1.7%) should be explained by the increased instability usually found in PD. In 2014, Oğuz *et al.* reported the interesting case of a 77-year-old

woman that experienced elective surgery due to fracture in the distal left tibia under spinal anaesthesia (22). Table 3 summarises the main complications that can take place after primary TKA in patients with PD.

**Survival of the implant in patients with PD**

In 2018, Rondon *et al.* revealed that the overall survival of TKA at 2, 5, and 10 years was 95.2%, 89.8%, and 66.2%, respectively (20). In 2019, Rong *et al.* found a survival rate of 87.5% at 60 months (12). In the study by Baek *et al.* published in 2021, a Kaplan–Meier survival analysis with revision of either component as an endpoint in the PD and control groups estimated an 89.7% and 98.3% chance of survival over 10 years, respectively (18). It should be noted that the three articles mentioned above show different survival rates that we can neither understand nor explain. Unfortunately, difficult-to-explain data such as these are frequent in the literature.

**Mortality after TKA in patients with PD**

In a level 3 prognostic type of evidence study, published in 2019 by Kleiner *et al.*, the hospital mortality rate was not higher in patients with PD (17). There was no significant difference in the inhospital mortality (0.164% vs 0.150%, *P* = 0.8465) between patients with PD and matched patients without PD. The hospital mortality rate was not higher in patients with PD, which allowed Kleiner *et al.* to state that this group could be safely considered for TKA (17).

**Table 3** Main complications after primary total knee arthroplasty (TKA) in patients with Parkinson’s disease (PD).

Complication	Comparison between groups		Reference
	PD group	MCs	
Global complication rate	26.3%	10.5%	Goh <i>et al.</i> (14)
Periprosthetic joint infection	6.5%	1.7%	Baek <i>et al.</i> (18)
Periprosthetic fracture	2.1%	1.7%	Baek <i>et al.</i> (18)
Flexion contracture	More frequent in PD group		Goh <i>et al.</i> (14)
90-day readmission rates	16.29%	12.66%	Marchand <i>et al.</i> (21)
Medical complications	4.21%	1.24%	Marchand <i>et al.</i> (21)
Implant-related complications	5.09%	3.15%	Marchand <i>et al.</i> (21)
Need for revision surgery	23.6% *		Rondon <i>et al.</i> (20)
Risk of any complication	44% higher risk		Newman <i>et al.</i> (19)
Risk of any medical complication	45% higher risk		Newman <i>et al.</i> (19)
Risk of any surgical complication	9% higher risk		Newman <i>et al.</i> (19)

\*5.3 years mean follow-up. MCs, matched controls.

**Table 4** Physical and mental health problems in patients with advanced Parkinson’s disease (PD) (24).

Physical problems	Mental problems
Falls	Cognitive decline and dementia
Extreme immobility	Depression
Sialorrhoea	Anxiety
Swallowing dysfunction	Apathy
Urinary dysfunction	Psychosis
Gastrointestinal dysfunction	Behavioural problems
Sleep disorders	Delirium

A higher mortality than that of the general population has been reported. Jansen *et al.* performed a case–control study on mortality after TKA in 857 patients with PD and compared it with 2571 MC patients. They observed that 34.7% of patients with PD and 59.7% of patients in the control group survived to 10 years of follow-up (23).

Although a direct comparison of mortality between studies is difficult to perform due to differences in demographics, such as age, sex, medical comorbidity, and ethnic differences, Rondon *et al.* concluded in 2018 that mortality after TKA in patients with PD was higher than that of the general population (20). Goh *et al.* found that the all-cause mortality was higher in the PD group (15.8% vs 5.3%,  $P = 0.067$ ) (14). According to Baek *et al.*, the cumulative mortality rates in the PD group and in the control group were 31% (9/29) and 6.9% (4/58) ( $P < 0.05$ ), respectively, at the final follow-up (18).

## Discussion

Advanced PD often presents with a range of motor and non-motor features that are difficult to manage (24). Medical treatments can be limited by adverse effects, and QoL can be severely affected by the accumulation of non-motor symptoms. In a recent publication, Gilbert and Khemani presented a practical approach to the management of advanced PD. They provided guidelines for managing the physical and mental problems of advanced PD (Table 4). They also defined advance care planning. These treatment guidelines and advance care planning are important for

neurologists, who should be part of the multidisciplinary team treating these patients but are beyond the scope of this article (24).

According to Baek *et al.*, it is expected that as patients with PD get older, the number of TKAs they will need in the future will increase. It stands to reason that as PD progresses, many TKA patients will experience severe physical disabilities and complications that could affect their ability to live independently. Although some studies prior to 2021 had published results of TKA in patients with PD, there had been few long-term studies. Therefore, until recently, the long-term clinical and radiological outcomes of TKA in patients with PD remained a controversial topic (18).

TKA is an effective surgical technique for pain relief, both in the short and in the long term. However, its functional outcome often worsens in the long term. In patients with PD, TKA is a difficult procedure that requires a holistic approach involving several specialists, including orthopaedic surgeons, neurologists, physiatrists, pain service staff, and geriatrics specialists, whose collaboration is necessary to ensure the success of the intervention (25).

TKA is a surgical technique that is often very successful in patients with advanced OA of the knee, restoring joint function without pain and providing good long-term outcomes. In 2018, however, Macaulay *et al.* stated that such outcomes were less predictable in people with PD (26) and that complication rates in the perioperative and postoperative periods were comparatively higher in people with PD than in patients without PD. Furthermore, achieving a good functional outcome was less certain than in the general population. Ultimately, they stated in 2010 that a number of important factors should be taken into account when deciding whether to implant a TKA in people with PD (26).

Macaulay *et al.* (26) published the following recommendations for TKA in patients with PD (26): (a) Only perform TKA after failure of nonsurgical measures and in the presence of debilitating knee pain; (b) Utilise

## RECOMMENDATIONS FOR TKA IN PATIENTS WITH PD

Holistic approach involving several specialists: orthopaedic surgeons, neurologists, physiatrists, pain service staff, geriatric specialists	Implant TKA only if conservative treatment has failed and knee pain is severe and disabling	Use PS or CCK or rotational hinge designs depending on the case	Utilise extremely well-padded splints in full extension in the postoperative period to prevent flexion contracture
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**Figure 2**

Recommendations for total knee arthroplasty (TKA) in patients with Parkinson’s disease (PD). PS, posterior stabilised; CCK, constrained condylar knee.

cruciate-retaining, condylar constrained kinetic, or hinged-knee devices in individuals with severe PD; (c) Do not use isolated femoral blockade, which might potentiate the early development of postoperative flexion contracture; (d) Use sciatic blockade or hamstring botulinum toxin type A injection; (e) Do not utilise continuous passive motion; and (f) Use extremely well-padded braces, splints, or casts in full extension. In the same article, Macaulay *et al.* reported the following contraindications for TKA in PD: (a) Any degree of preoperative delirium; (b) Patient is not a candidate for regional anaesthesia, or TKA is not possible (e.g. due to body habitus) and general anaesthesia is the only alternative; (c) Opiates needed in the postoperative period; (d) Multidisciplinary team members are not available (e.g. orthopaedic staff, neurologist, pain service staff, highly trained nursing staff, geriatric specialist, and physiatrist); (e) Hoehn and Yahr rating  $\geq 3$ ; (f) Knee flexion contracture  $>25^\circ$  before surgery; and (g) Lack of response to preoperative diagnostic bupivacaine hydrochloride injection (26). In 2018, Wong *et al.* stated that PD should not be an absolute contraindication for implanting a TKA in patients with PD (7).

The main limitations of this study are twofold: (a) only two of the existing databases (PubMed/MEDLINE and The Cochrane Library) have been used; although we consider them to be the most important, they are obviously not all the currently existing ones; (b) The criteria for inclusion or exclusion of articles were based on our subjective decision whether or not to consider them fully related to the title of the article (primary TKA in PD).

## Conclusions

PD is a common neurodegenerative disorder, the most important risk factor for which is age, with prevalence rising from 1% in the 45–54-year age group to 2–4% in the 85+ age group. The increasing population predicts that we will face a ‘PD pandemic’ in the future and that its prevalence will double in the next 20 years. If appropriately medically treated, patients with PD can live up to 10 years after being diagnosed with the disease. These patients can also acquire advanced and painful knee OA requiring the implantation of a primary TKA.

After TKA, functional ability does not improve in patients with PD, and functional loss has been reported in patients with last-stage PD. Poorer knee function has been found compared with MCs, and LOS after TKA is also increased compared with MCs. However, we do not want to give a very negative impression of carrying out TKA in PD.

Figure 2 shows our recommendations for TKA implantation in patients with PD. We consider that there is currently no absolute contraindication for such an intervention. However, it should be noted that

patients with PD have a higher risk of complications (PJI, periprosthetic fracture, and postoperative flexion contracture) than patients without PD. In addition, long-term implant survival is lower than in people without PD. Orthopaedic surgeons, patients with PD, and their families should take this information into account when faced with the decision whether to implant a TKA.

### ICMJE Conflict of Interest Statement

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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