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ORIGINAL STUDY

Is Parkinson's disease associated with worse outcomes following hip replacement for treatment of acute hip fracture?

James Pallot, Maziar Mohaddes, Daniel Odin, Cecilia Rogmark, Peter Cnudde

From the Department of Orthopaedics, Prince Philip Hospital, Hywel Dda University Healthboard, Bryngwynmawr, Llanelli, UK

The prevalence of Parkinson's disease (PD) is increasing. Targeted research evaluating clinical outcomes following hip arthroplasty (HR) for acute hip fractures in this high-risk group of patients is lacking. This study evaluates whether PD is associated with worse outcomes with regards to revision rate and mortality in patients who sustain hip fractures treated with total or hemiarthroplasty.

Between 2005 and 2012, 1,204 patients with PD who underwent HR surgery following acute hip fracture were identified in the Swedish Hip Arthroplasty Register (SHAR). A control group was generated, with 1 :1 exact matching for potentially confounding variables. Risks of revision and mortality were compared at predetermined intervals over a six-year study period, using Kaplan-Meier and Log-rank testing.

No significant differences were detected in revision rates between PD and control groups at 30 days (p=0.71), 90 days (p=0.85), one-year (p=0.51) and six-years (p= 0.40). Increased mortality was observed in the PD group at all time periods assessed. Log-rank testing identified these differences to be significantly higher at 90 days (p<0.01) and on completion of the six-year study period (p<0.001). Differences in mortality rates observed at interim periods of 30 days (p=0.06) and one year (p=0.07) were not shown to be of statistical significance.

Patients with PD had increased risk for mortality following total or hemiarthroplasty after a hip fracture, however we were unable to identify an increased risk of revision. As increased incidence of hip fracture sustained by PD patients is predicted, multidisciplinary care must be prioritised to improve outcomes.

Keywords : Parkinson's disease ; arthroplasty ; hip fracture ; mortality ; revision ; register.

INTRODUCTION

The prevalence of Parkinson's disease (PD) across European populations is increasing *(24)*.

■ James PALLOT[1],
■ Maziar MOHADDES[2,3],
■ Daniel ODIN[2],
■ Cecilia ROGMARK[2,4],
■ Peter CNUDDE[1,2,3]

[1]*Department of Orthopaedics, Prince Philip Hospital, Hywel Dda University Healthboard, Bryngwynmawr, Llanelli, SA14 8QF, UK*

[2]*Swedish Hip Arthroplasty Register, Registercentrum Västra Götaland, Medicinargatan 18G, Gothenburg, SE 41 435, Sweden*

[3]*Department of Orthopaedics, Institute of Clinical Sciences, Sahlgrenska Academy, Gothenburg University, SE 41 435, Sweden*

[4]*Department of Orthopaedics, Lund University, Skåne University Hospital, SE 221 85, Sweden*

Correspondence : James PALLOT, Department of Orthopaedics, Prince Philip Hospital, Hywel Dda University Healthboard, Bryngwynmawr, Llanelli, SA14 8QF, UK

E-mail : jamespallot@icloud.com

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Disease onset is rare before age 50. However, a marked increase in incidence from age 60 onwards has led to PD being reported as the second most common chronic neurodegenerative condition in older people in Europe after Alzheimer's disease *(8)*. Meta-analysis of worldwide data demonstrates disease prevalence to be 41 per 100,000 at age 40-49 years increasing to 1,903 per 100,000 in individuals aged over 80 *(19)*. The risk of hip fractures has also been demonstrated to grow with increasing age. The disease burden generated by each condition is anticipated to impart significant demands on healthcare resources and is forecast to grow further as the population ages *(10)*.

Patients diagnosed with PD have a two-fold increased risk of all fractures *(7)*, and an estimated three to four fold increase in risk of hip fractures *(1,25)*. Multiple pathophysiological mechanisms associated with the disease process may be implicated. Greater incidence of falls has been attributed to motor symptoms and gait disturbance in combination with non-motor symptoms where an impaired cognition compounds this risk *(17)*. Further evidence has indicated that patients diagnosed with PD have a reduced bone mineral density *(22)*. Immobility and a coinciding decreased muscle strength, and low body weight may also be implicated in this group. Additionally, hyperhomocysteinaemia, an independent risk factor for osteoporosis, is common in PD due to use of dopaminergic drugs *(23)*.

While several options are available for the acute surgical management of patients with a displaced femoral neck fracture, a growing body of evidence supports hemi- or total hip arthroplasty as a definitive treatment in the elderly *(6,15)*. Total hip arthroplasty appears to be particularly advantageous for active, lucid patients with a relatively long life expectancy as functional outcomes are shown to be superior for total hip arthroplasty when compared to hemiarthroplasty *(11)*. However, despite the commonly described increased risk of revision and mortality in patients with neurological conditions, there is only limited knowledge about the risk for revision and mortality in PD patients undergoing arthroplasty for acute hip fractures *(4,14,21)*.

The aim of this study is to analyse whether a pre-operative diagnosis of Parkinson's disease is associated with worse outcomes with regards to revision rate and mortality in hip fracture patients treated with total or hemiarthroplasty, compared to those without PD.

PATIENTS AND METHODS

A retrospective case-control study design was employed using nationwide prospectively collected data. The SHAR allows identification of all patients who underwent total arthroplasty or hemiarthroplasty for management of acute hip fractures in Sweden. A seven year period from 2005 to 2012, was chosen because of the possibility to obtain additional patient information due to the linking of data between the SHAR and governmental administrative databases from Swedish National Patient Register *(12)* and Statistics Sweden *(3)*. Using the integrated research database we were able to access three levels of data, with regards to patient demographics, patient related variables, surgery-related variables and outcomes *(13)*. Baseline patient demographic information consisted of age at time of surgery, sex and date of procedure. Further surgery-related information on type of hospital, approach, procedure, revisions, and date of death was obtained. Patient-related data consisted of ASA score, BMI and comorbidities, with a Charlson comorbidity index (CCI) to gauge overall health *(5)*. Patients with a confirmed pre-operative diagnosis of PD were identified on the SHAR-linked database (Figure 1) using relevant code identifiers from the World Health Organization International Classification of Diseases and Health Related Problems (ICD-10) system employed by the database *(20)*. An additional cohort of patients who had also sustained hip fractures requiring total or hemiarthroplasty was selected from the database to form a control group to permit comparison of outcomes. This group was generated by an exact 1-1 matching of each patient with a pre-operative diagnosis of PD to a patient without a diagnosis of PD who underwent a similar procedure for management of a hip fracture controlling for age, sex, CCI (based on preoperative recording of comorbidities one year prior to the acute hip fracture) along with procedure performed (hemi or total arthroplasty), year of procedure and surgical approach employed

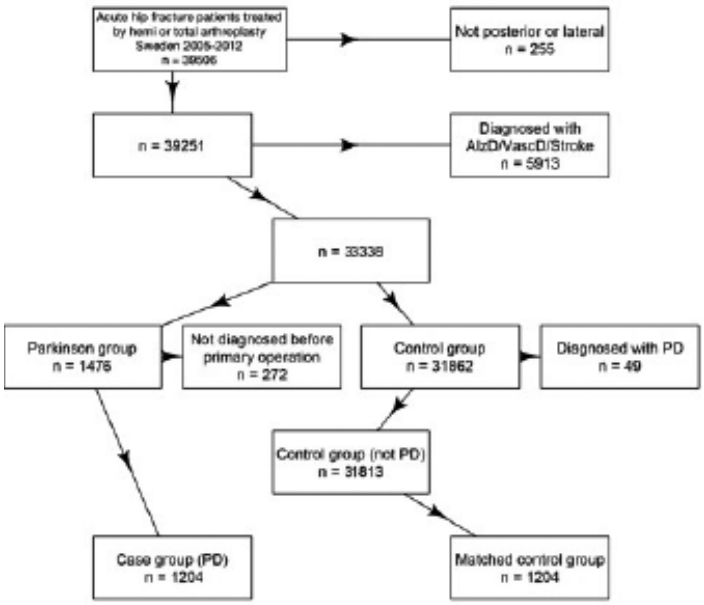

Figure 1. — Sample Identification and inclusion flow chart.

(posterior or lateral approach utilised). Patients who experienced sequelae including stroke and/or dementia and those who were diagnosed with PD in the postoperative period were excluded from both the study as well as the control group.

The primary outcome assessed was revision rates recorded at set time intervals for PD and control groups following hemi or total arthroplasty for treatment of hip fracture. The secondary outcome measured was mortality rates observed in each group at the same intervals. The third outcome investigated was a sub-analysis of documented indications for revision procedures recorded for PD and control groups. Indications for revision surgery are grouped into corresponding clinical categories and displayed numerically and as a percentage representing the contribution of each category towards the total number of revision procedures performed at the time period specified.

Revision procedures are defined as any operation involving removal, addition, modification or replacement of a prosthetic component post arthroplasty surgery *(16)*. Complications requiring surgery post hemi or total arthroplasty are routinely disclosed for registration by the SHAR database. Annual review of this process is performed, demonstrating that 92-93% of cases requiring revision are captured by the SHAR.

Risk of revision and mortality were analysed at set intervals of 30 days, 90 days, one year and six years, using Kaplan-Meier and Log-rank testing. Group comparisons were performed by using one-way t-test for continuous variables and chi-square test for categorical variables, significance level was set at $p<0.05$. Statistical analysis was performed using R Statistical Software (R Foundation for Statistical Computing, Vienna, Austria).

Ethical review approval to study a multidimensional outcomes assessment following hip arthroplasty surgery and to develop the crosslinked dataset which is the foundation for this study was obtained on 9/04/2014 from the Regional Ethical Review Board in Gothenburg, Sweden (Dnr 271-14).

RESULTS

In the period 1/01/2005-31/12/2012 39,506 total or hemiarthroplasties were recorded for acute hip fractures. 1204 patients with confirmed diagnosis of PD, prior to the hip fracture were identified. Table I provides descriptive statistics including age, gender, Charlson comorbidity score, procedure and surgical

Table I. — Patient demographics of the control and study group (PD)

	Control group	Parkinson's Disease group
Number	1204	1204
Mean Age (SD)	79.37 (6.7)	79.34 (6.8)
Age group (%)		
Age <70	101 (8.4)	102 (8.5)
Age 70-80	533 (44.3)	533 (44.3)
Age 80-90	535 (44.4)	534 (44.4)
Age >90	35 (2.9)	35 (2.9)
Sex Male (%)	534 (44.4)	534 (44.4)
Sex Female (%)	670 (55.6)	670 (55.6)
Charlson Comorbidity Index Score (CCI)(%)		
0	847 (70.3)	847 (70.3)
1	191 (15.9)	191 (15.9)
2	93 (7.7)	93 (7.7)
3	49 (4.1)	49 (4.1)
4	14 (1.2)	14 (1.2)
5	2 (0.2)	2 (0.2)
6	847 (70.3)	847 (70.3)
7	191 (15.9)	191 (15.9)
8	93 (7.7)	93 (7.7)
Total Hip arthroplasty performed (%)	175 (14.5)	175 (14.5)
Hemiarthroplasty performed (%)	1029 (85.5)	1029 (85.5)
Surgical Approach = Lateral (%)	694 (57.6)	694 (57.6)
Surgical Approach = Posterior (%)	510 (42.4)	510 (42.4)
ASA (%)		
1	48 (6.9)	6 (0.9)
2	294 (42.2)	228 (32.7)
3	317 (45.5)	432 (62.0)
4	36 (5.2)	31 (4.4)
5	1 (0.1)	0 (0.0)

approach. As a result of the exact 1:1 matching of the PD and control groups there were no significant differences with regards to baseline demographics as listed above. 1152 (96%) and 1127 (94%) of implants used in control and PD groups respectively utilised cemented stem fixation.

Within the PD group 51 participants (4.2%) required revision surgery over the six-year follow-up period with a similar figure of 50 participants (4.2%) observed in the control group (Table II). Log rank testing revealed no significant differences in revision conducted at any point throughout the

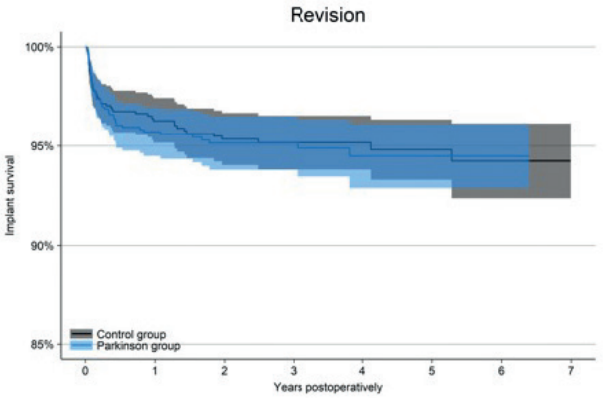

Figure 2. — Kaplan-Meier Survival Analysis (95% CI) with implant revision as endpoint.

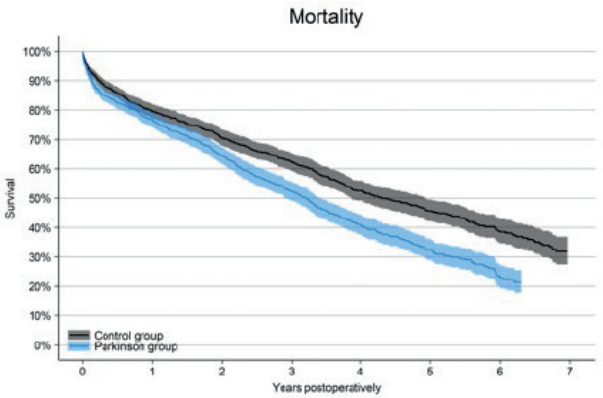

Figure 3. — Kaplan-Meier survival analysis (95% CI) with death as endpoint.

study. At 30 days p=0.71, at 60 days p=0.85, at 1-year p=0.52 and at 6 years p= 0.77 (Fig 2). A sub analysis of indications for performing revision procedures was performed and compared between the two groups using chi-squared test. While there was a tendency towards higher number of dislocations in the PD group, we failed to show any statistically significant difference at the different time intervals (Table III).

Increased mortality was observed in the PD group at all time periods assessed. Within the PD group, 654 patients (54.3%) died over the six-year follow-up period compared to 529 mortalities (43.9%) seen in the control group (Table II). Log rank testing identified these differences to be significantly higher at 90 days ($p<0.01$) and on completion of the entire six-year study period ($p<0.001$). Differences

Table II. — Overall revision rates following treatment and mortality observed for the entire population of patients sampled at the specified intervals. Kaplan-Meier Survival analysis with 95% confidence intervals (CI) and Log-rank test results are demonstrated. Significant results ($p<0.05$) marked by *.

Post-operative time period	Control Group (Absolute number)	Number of Participants at risk Control Group (Absolute number)	Kaplan-Meier survival analysis (95% CI) Revision= implant survival as endpoint Mortality = Death as endpoint			Parkinson's Disease Group (Absolute number)	Number of Participants at risk PD Group (Absolute number)	Kaplan-Meier survival analysis (95% CI) Revision= implant survival as endpoint Mortality = Death as endpoint			p-value (Log-rank)
			Survival	Lower (95% CI)	Upper (95% CI)			Survival	Lower (95% CI)	Upper (95% CI)	
Revision											
30 days	17	1099	0.99	0.98	0.99	17	1085	0.98	0.98	0.99	0.71
90 days	32	1017	0.97	0.96	0.98	33	980	0.97	0.96	0.98	0.85
1 year	40	806	0.96	0.95	0.97	45	768	0.96	0.94	0.97	0.52
6 years	50	100	0.94	0.92	0.96	51	62	0.94	0.93	0.96	0.77
Mortality											
30 days	71	1116	0.94	0.93	0.95	94	1102	0.92	0.91	0.94	0.06
90 days	124	1045	0.90	0.88	0.91	167	1011	0.86	0.84	0.88	<0.01*
1 year	236	831	0.79	0.77	0.82	271	802	0.77	0.74	0.79	0.07
6 years	529	104	0.39	0.35	0.43	654	62	0.23	0.19	0.27	<0.001*

Table III. — Revision indication at the different time intervals for study and control group. Absolute numbers and percentages are given

Indication for revision surgery by category	Control Group	Parkinson's Disease Group	p-value
30 days (%)			0.3
Aseptic loosening	1 (5.9)	0 (0.0)	
Dislocation	9 (52.9)	10 (58.8)	
Periprosthetic fracture	0 (0.0)	2 (11.8)	
Periprosthetic infection	7 (41.2)	5 (29.4)	
90 days (%)			0.6
Aseptic loosening	1 (3.1)	0 (0.0)	
Dislocation	16 (50.0)	20 (60.6)	
Infection + dislocation	1 (3.1)	2 (6.1)	
Periprosthetic fracture	2 (6.2)	3 (9.1)	
Periprosthetic infection	12 (37.5)	8 (24.2)	
1 year (%)			0.2
Acetabulum erosion	1 (2.5)	0 (0.0)	
Aseptic loosening	2 (5.0)	0 (0.0)	
Dislocation	16 (40.0)	29 (64.4)	
Infection + dislocation	1 (2.5)	2 (4.4)	
Periprosthetic fracture	7 (17.5)	6 (13.3)	
Periprosthetic infection	13 (32.5)	8 (17.8)	
6 years (%)			0.1
Acetabulum erosion	5 (10.0)	1 (2.0)	
Aseptic loosening	4 (8.0)	1 (2.0)	
Dislocation	18 (36.0)	30 (58.8)	
Infection + dislocation	1 (2.0)	2 (3.9)	
Periprosthetic fracture	8 (16.0)	9 (17.6)	
Periprosthetic infection	13 (26.0)	8 (15.7)	
Other symptoms	1 (2.0)	0 (0.0)	

in mortality rates observed at interim periods of 30 days (p=0.06) and one year (p=0.07) were not shown to be of statistical significance (Fig 3).

DISCUSSION

Our results evaluate arthroplasty as a treatment for displaced femoral neck fractures in PD patients. While the alternative treatment of internal fixation is not studied in our material, contemporary research shows internal fixation to be inferior in terms of functional outcome and pain relief when assessing treatment outcomes for populations sustaining hip fractures as a whole *(6)*. It is likely that patients with PD may potentially fare worse from internal fixation with a more prolonged and painful recovery compared to patients without neurological impairment. When the adverse recovery period amongst PD patients is considered, demonstrating that arthroplasty represents a safe alternative is of clinical importance.

We were unable to show an increased revision rate following arthroplasty for acute hip fractures in individuals with Parkinson's disease during the six-year follow-up period. Our data does, however, show a higher postoperative mortality in the PD group. Hip fracture patients usually have one or several comorbidities. Many of the patients included in the studies may be approaching the end of their life. Evaluating outcomes for patients with progressive neurodegenerative conditions in the longer term is a desirable goal, however this remains a challenge and data is scant in literature available to date *(4,14,15,18,21)*. We believe that the use of data based on a nationwide prospective collection may contribute to this pursuit.

Available literature comparing mortality and risk for revision after arthroplasty for acute hip fractures in properly matched cohorts of PD and non-PD patients is sparse at present. Karadesh et al. performed a retrospective case-controlled analysis of 141 patients. Their study group received surgical treatment for acute fracture of the femoral neck, with both internal fixation as well as arthroplasty. They reported an increased risk of revision surgery and increased mortality for patients diagnosed with PD. At three-year follow-up, 85% of their PD patients were revision free, compared to 95% in the control group. Five-year mortality was 90% and 70% respectively *(14)*. Sponer et al. investigated 13 patients who received a THA following an acute hip fracture. They describe a one-year mortality rate of 28.6 % *(21)*. In contrast with both studies, our relatively large series of PD patients failed to demonstrate a higher revision rate than the matched control group of non-PD patients. Relatively few patients in both PD and control groups required revision surgery at any time interval assessed. Despite our larger sample size, the small number of participants necessitating revision imparts limited statistical power to identify significant differences between categorical indications for revision surgery registered. A non-significant tendency towards increased rates of dislocation observed in the PD compared to the matched control group is in keeping with published research *(4,14)*.

We found an increased mortality in those diagnosed with PD, this finding confers with available literature. A retrospective observational cohort study with a maximum follow up period of eight years evaluated 131,215 patients with a diagnosis of PD who had sustained hip or pelvic fractures. The risk of death for patients with PD was shown to be greater than double than that seen for matched control groups *(9)*. In contrast, a similar retrospective observational study of 371 patients with a sole diagnosis of PD over a one-year follow-up period, did not identify any significant association between PD and increased mortality following hip fracture *(2)*. Older literature reviews *(4)* also provide contradictory statements regarding mortality rates and the reoperation rates observed. These findings are likely to be associated with variations in operative techniques employed, consideration of potential confounding factors between the PD and control patients and methodology used across the studies considered. The strength with the current study is exact matching of differences in demographic data and comorbidity data on PD and non-PD patients.

A potential point of contention may arise with regards to use of Charlson's comorbidity index to match PD and control groups in terms of comorbidity when comparisons are made to the ASA scoring system. Greater proportions of

patients in the control group were allocated lower ASA scores prior to admission compared to patients in the PD group. This discrepancy is explained by the ASA subjective scoring system including PD as part of its analysis, whereas the CCI does not specifically allocate points in its scoring system for a diagnosis of PD. Therefore, in terms of ASA, the PD group in our study could be considered to have had poorer health, despite this not being reflected in CCI scoring.

An effective study of this topic can only be facilitated using large integrated datasets. The sizeable pool of patients provided by such resources generates statistical power to identify potentially significant differences in groups studied. We argue that the data contained within the Swedish Hip Arthroplasty Register (SHAR) could provide an ideal platform as this nationwide database commenced recording all kinds of arthroplasty for hip fractures in 2005. We have been able to create an integrated data that spans over seven years *(3)*, incorporating almost all cases from a population of approximately 10 million. Our study had several limitations. Firstly, those who undergo surgical fixation of hip fractures via methods not common in Sweden cannot be evaluated by this study. As a result, investigation of outcomes associated with cemented versus non-cemented means of implant fixation could not be performed adequately as the great majority of implants used in control and PD groups utilised cemented fixation. Furthermore, we cannot identify patients who have sustained concomitant injuries such as additional fractures. Second, while details of highly significant complications requiring surgical revision in theatre are recorded reliably on the SHAR database, patients experiencing other adverse outcomes post-hemi or total arthroplasty may potentially be overlooked. Conditions requiring surgical intervention not classified as a revision along with non-surgical management strategies are not evaluated. Examples include management of complications such as closed reduction of hip dislocations and simple washout for infections and antibiotic suppression. Third, patients deemed to be high risk and potentially unsuitable for further operative intervention may bypass analysis in the study and, despite the fact that the primary treatment failed it is recorded as a "success" in the absence of revision surgery. The lack of incorporation of such data in national registries precludes evaluation of the impact of these factors on patient outcomes. Finally, drop-out rates and patients lost to follow up (attrition bias) must be considered in a study of this nature, however we are confident that as a result of the nationwide collection and the interaction with a national population register all cases of mortality and more than 90% of revisions have been accounted for.

CONCLUSION

Patients with Parkinson's disease had worse long-term mortality following total or hemiarthroplasty due to acute hip fracture. The risk of revision surgery was similar to that observed in a matched control group. An increased incidence of hip fracture sustained by PD patients mandates a true multidisciplinary approach should be employed to improve outcomes.

Contributors : JP interpretation of data, first draft of the article, critical revision ; MM design of study, interpretation of data, data analysis, critical revision ; DO : interpretation of data, data analysis, acquisition of data, critical revision ; CR : interpretation of data, data analysis, critical revision ; PC : conception and design of study, interpretation of data, data analysis, draft of the article, critical revision.

All authors have read and approved the final manuscript.

REFERENCES

1. **Benzinger P, Rapp K, Maetzler W, et al.** Risk for femoral fractures in Parkinson's disease patients with and without severe functional impairment. *PLoS One*. 2014 ; 9 : e97073.
2. **Chiu H CC, Su T, Chen C, Hsieh H, Hsieh C, Shen D**. Dementia predicted one-year mortality for patients with first hip fracture. *Bone Joint J.* 2018 : 1220-1226.
3. **Cnudde P, Rolfson O, Nemes S, et al.** Linking Swedish health data registers to establish a research database and a shared decision-making tool in hip replacement. *BMC Musculoskelet Disord*. 2016 ; 17 : 414.
4. **Critchley RJ, Khan SK, Yarnall AJ, et al.** Occurrence, management and outcomes of hip fractures in patients with Parkinson's disease. *Br. Med. Bull*. 2015 ; 115 : 135-142.

5. **de Groot V, Beckerman H, Lankhorst GJ, Bouter LM**. How to measure comorbidity. A critical review of available methods. *J. Clin. Epidemiol*. 2003 ; 56 : 221-229.
6. **Gao H, Liu Z, Xing D, Gong M**. Which is the best alternative for displaced femoral neck fractures in the elderly? : A meta-analysis. *Clin. Orthop. Relat. Res*. 2012 ; 470 : 1782-1791.
7. **Genever RW, Downes TW, Medcalf P**. Fracture rates in Parkinson's disease compared with age- and gender-matched controls : a retrospective cohort study. *Age Ageing*. 2005 ; 34 : 21-24.
8. **Group NDC**. Global, regional, and national burden of neurological disorders during 1990-2015 : a systematic analysis for the Global Burden of Disease Study 2015. *Lancet Neurology*. 2017 ; 16 : 877-897.
9. **Harris-Hayes M, Willis AW, Klein SE, *et al.*** Relative mortality in U.S. Medicare beneficiaries with Parkinson disease and hip and pelvic fractures. *J. Bone Joint Surg. Am*. 2014 ; 96 : e27.
10. **Hernlund E, Svedbom A, Ivergard M, *et al.*** Osteoporosis in the European Union : medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch. Osteoporos*. 2013 ; 8 : 136.
11. **Hopley C, Stengel D, Ekkernkamp A, Wich M**. Primary total hip arthroplasty versus hemiarthroplasty for displaced intracapsular hip fractures in older patients : systematic review. *BMJ*. 2010 ; 340 : c2332.
12. **https://www.socialstyrelsen.se**. The Swedish National Patient Register [updated 09/09/2018. Available from : https://www.socialstyrelsen.se/register/halsodataregister/patientregistret/inenglish.
13. **Inacio MC, Paxton EW, Dillon MT**. Understanding Orthopaedic Registry Studies : a Comparison with Clinical Studies. *J. Bone Joint Surg. Am*. 2016 ; 98 : e3.
14. **Karadsheh MS, Rodriguez EK, Harris MB, *et al.*** Mortality and Revision Surgery Are Increased in Patients With Parkinson's Disease and Fractures of the Femoral Neck. *Clin Orthop Relat Res*. 2015 ; 473 : 3272-3279.
15. **Leonardsson O, Sernbo I, Carlsson A, *et al.*** Long-term follow-up of replacement compared with internal fixation for displaced femoral neck fractures : results at ten years in a randomised study of 450 patients. *J. Bone Joint Surg. Br*. 2010 ; 92 : 406-412.
16. **Liebs TR, Splietker F, Hassenpflug J**. Is a Revision a Revision? An Analysis of National Arthroplasty Registries' Definitions of Revision. *Clin. Orthop. Relat. Res*. 2015 ; 473 : 3421-3430.
17. **Melton LJ, 3rd, Leibson CL, Achenbach SJ, *et al.*** Fracture risk after the diagnosis of Parkinson's disease : Influence of concomitant dementia. *Mov. Disord*. 2006 ; 21 : 1361-1367.
18. **Neuman MD, Silber JH, Magaziner JS, *et al.*** Survival and functional outcomes after hip fracture among nursing home residents. *JAMA Intern. Med*. 2014 ; 174 : 1273-1280.
19. **Pringsheim T, Jette N, Frolkis A, Steeves TD**. The prevalence of Parkinson's disease : a systematic review and meta-analysis. *Mov. Disord*. 2014 ; 29 : 1583-1590.
20. **Quan H, Sundararajan V, Halfon P, *et al.*** Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med. Care*. 2005 ; 43 : 1130-1139.
21. **Sponer P, Kucera T, Grinac M, *et al.*** The Outcomes of Total Hip Replacement in Patients with Parkinson's Disease : Comparison of the Elective and Hip Fracture Groups. *Parkinsons Dis*. 2017 ; 2017 : 1597463.
22. **Torsney KM, Noyce AJ, Doherty KM, *et al.*** Bone health in Parkinson's disease : a systematic review and meta-analysis. *J. Neurol Neurosurg. Psychiatry*. 2014 ; 85 : 1159-1166.
23. **van den Bos F, Speelman AD, Samson M, *et al.*** Parkinson's disease and osteoporosis. *Age Ageing*. 2013 ; 42 : 156-162.
24. **von Campenhausen S, Bornschein B, Wick R, *et al.*** Prevalence and incidence of Parkinson's disease in Europe. *Eur. Neuropsychopharmacol*. 2005 ; 15 : 473-490.
25. **Walker RW, Chaplin A, Hancock RL, *et al.*** Hip fractures in people with idiopathic Parkinson's disease : incidence and outcomes. *Mov. Disord*. 2013 ; 28 : 334-340.