Predicting the Longer-term Outcomes of Total Hip Replacement

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ABSTRACT. ***Objective.*** The objective of this study was to identify the patient-level predictors (age, sex, body mass index, mental health, and comorbidity) for a sustained functional outcome at a minimum 1 year of followup after total hip replacement (THR).

Methods. We reviewed data from our registry on 636 consecutive patients from 1998 to 2005. Demographic data and the outcome scores of the Western Ontario McMaster University Osteoarthritis Index (WOMAC) and Medical Outcomes Study Short-form 36 (SF-36) scores were extracted from the database. Longitudinal regression modeling was performed to identify the predictive factors of interest. Fourteen percent of patients were missing outcomes data at 1 year of followup.

Results. The mean followup in our cohort was 3.3 years (range 1–6 yrs) and there were no revisions for aseptic loosening performed during this time. Mean clinical outcome scores were found to be relatively constant for the 6 years after surgery. Older age, year of followup, and greater comorbidity were identified as negative prognostic factors for a sustained functional outcome following THR ($p < 0.05$).

Conclusion. Understanding of longterm surgical outcomes should be appropriately used to set realistic patient expectations of surgery. (First Release September 1 2010; J Rheumatol 2010;37:2573–7; doi:10.3899/ jrheum.100149)

Key Indexing Terms:
HIP ARTHROPLASTY COMORBIDITY MENTAL HEALTH OUTCOMES

Hip osteoarthritis (OA) is a major cause of pain and disability in the elderly and has a severe effect on health-related quality of life (HRQOL)[1,2]. Total hip replacement (THR) is the recommended treatment for severe OA of the hip[3], and it has evolved to become one of the most successful orthopedic surgical interventions to date[4].

Despite significant improvements in our understanding of the health benefits of THR, literature on predictors of an improved longterm outcome is limited. Knowledge of determinants of prognosis allows the surgeon to appropriately counsel patients on realistic expectations and determine the optimal timing of surgery. Factors such as age[5,6,7,8], female gender[8], and preoperative level of disability[5,6,7] have been suggested as decreasing longterm function. Only a few studies examining THR longterm outcomes have used longitudinal analysis or repeated measures analysis[9,10]. This statistical method uses all data points between baseline and the latest followup, evaluating the effect of time on an outcome. It is essential to account for the effect of time and aging on health outcomes, because population-based studies have shown that HRQOL decreases with older age[11,12].

Our primary objective was to use longitudinal regression modeling to identify the predictors for a sustained patient functional outcome following THR for OA at a minimum of 1 year of followup. The null hypothesis was that age, gender, body mass index (BMI), mental health, and comorbidity do not predict hip arthroplasty outcomes.

MATERIALS AND METHODS

Study sample. In our center, we prospectively enroll for our registry patients who are on a waiting list for primary hip replacement surgery. All patients gave consent to participate to a research coordinator not involved in the medical care of the patients. All data were collected by patient self-report questionnaires. Our inclusion criteria for this study were patients at least 18 years of age at the time of surgery, a diagnosis of primary OA, unilateral surgery, and a minimum 1-year followup. All surgeries were performed by 1 of 2 fellowship-trained arthroplasty surgeons between 1998 and 2005. The study protocol was approved by the Human Subject Review Committee.

Before 2001, surgeries involved a combination of cemented and uncemented implants. After this, uncemented THR became the standard at our center.

Collection of data. We extracted baseline demographic data of age, sex, BMI, and comorbidity from our database. BMI was defined as body weight in kilograms divided by height in meters squared (m^2). Comorbidity was defined by the 14 categories of chronic illness adapted from the Cumulative Illness Rating Scale (CIRS)[13,14]. The CIRS covers the domains of cardiac; vascular; hematological; respiratory; otorhinolaryngological and ophthalmological; upper gastrointestinal; lower gastrointestinal; hepatic and pancreatic; renal; genitourinary; musculoskeletal and tegumental; neurological; endocrine, metabolic, and breast; and psychiatric systems.

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Patient functional status was assessed preoperatively and then annually with the Western Ontario McMaster University Osteoarthritis Index (WOMAC)[15]. This scale consists of 24 items encompassing the domains of pain, function, and stiffness. A greater score on the WOMAC scale represents poorer function or greater pain and stiffness[15,16]. Patient HRQOL was assessed by the Medical Outcomes Study Short-form 36 (SF-36) preoperatively and at yearly followups[17,18,19]. The SF-36 has 8 subscales that generically measure health status using a 0–100 scoring scale[20]. Contrary to the WOMAC, a higher SF-36 score represents better HRQOL.

The minimal clinically important difference (MCID) describes a more clinically oriented measurement of outcome at the individual level. The MCID is defined as the smallest difference in a score that a patient would perceive as beneficial[21]. The MCID for the total WOMAC score has been suggested to lie between 7.5 and 15 points[22,23,24]. The MCID for the components scale of the SF-36 has been estimated at about 15 points[23].

Statistical analysis. In our dataset of 636 consecutive patients, each patient contributed a minimum of 2 functional scores (baseline and at least 1-year followup). Missing data in a longitudinal analysis indicate that not all patients have full data for all points of followup[21]. The options for managing missing data include last value carried forward, multiple imputation, or to leave the data as missing[25]. Multiple imputation assumes normally distributed data and involves a mathematical determination of what the likely value of the missing data point would be[25]. The generalized estimating equations method is commonly used because it accounts for the within-subject correlation between repeated measures and also because it includes all provided followup data from each subject, even if the data are not complete[26]. Analysis performed with multiple imputation and by leaving the data missing provided very similar results and therefore we present the data without imputation.

We fit multivariable longitudinal regression models to identify those factors that predict an improved functional status following hip replacement surgery at a minimum of 1 year of followup. With this technique, yearly followup scores on the same patient are not considered independent. Separate models were created for each of the 3 dependent variables, the total WOMAC score, the SF-36 Physical Function (PF) score, and the SF-36 Role Physical (RP) score. In longitudinal regression, the dependent variables are the corresponding change in the outcome score from year to year, and thus naturally adjust for baseline level of function. The covariates entered into the models were age, gender, BMI, SF-36 Mental Health (MH) scores, method of fixation (cemented vs uncemented), and comorbidity. All covariates were retained in the models whether significant or not, to maintain face validity of the models.

All statistical analyses were performed with SPSS version 13.0 (SPSS, Chicago, IL, USA). Measurement estimates for regression modeling and their 95% CI are reported. All reported p values are 2-tailed, with an α of 0.05.

RESULTS

The mean followup for our cohort of 636 hip replacement patients was 3.3 years (range 1–6 yrs). The demographic data and baseline functional scores for the cohort are given in Table 1. No patients required revision surgery for aseptic loosening during the study. At the 1-year followup, 14% of patients did not provide data on the outcome of total WOMAC scores. There were no clinical differences in age, sex distribution, BMI, or medical comorbidity between those who returned data at the 1-year followup as compared to those who did not.

Figures 1–3 show the mean total WOMAC, mean SF-36 PF, and mean SF-36 RP scores for our cohort across the years of followup, with patient numbers at each year of followup. Functional outcomes appear to be relatively constant for 6 years following hip replacement surgery on all outcome measures.

Table 1. Demographic data and baseline functional scores for the hip replacement cohort (n = 636).

Characteristic	
Mean age, yrs (SD)	63.2 (13.7)
Men, %	46.5
Mean BMI kg/m^2 (SD)	27.6 (4.9)
Mean comorbidity (SD)	2.5 (1.5)
Mean baseline WOMAC score (SD)	54.4 (17.1)
Mean baseline SF-36 Physical Function score (SD)	24.3 (19.9)
Mean baseline SF-36 Role Physical score (SD)	16.9 (30.9)

BMI: body mass index; WOMAC: Western Ontario McMaster University Osteoarthritis Index; SF-36: Medical Outcomes Study Short-form 36.

Longitudinal regression showed that year of followup, an older age, and greater comorbidity were predictive of a less sustained functional outcome on the WOMAC scale ($p < 0.05$; Table 2). The WOMAC score increases 0.88 points for every year of followup, 0.25 points for each increased year of age, and 2.15 points for each added comorbidity. This suggests that after 6 years of followup, a patient is likely to have a significantly poorer outcome as compared to someone 10 years younger with 2 fewer medical comorbidities.

For the outcome of SF-36 PF, year of followup, male gender, older age, and greater comorbidity predicted a less sustained functional outcome ($p < 0.05$; Table 3). The PF score decreases 1.61 points for every year of followup, 5.18 points for men as compared to women, 0.29 points for each increased year of age, and 5.08 points for each additional comorbidity. This suggests that after 6 years, a male patient is likely to have a significantly poorer outcome as compared to a female patient who is 5 years younger with 1 less comorbidity.

For the outcome of SF-36 RP, older age and greater comorbidity were independent predictors of a poorer outcome ($p < 0.05$; Table 4). Year of followup demonstrated borderline significance ($p = 0.05$). The RP score decreases 0.54 points for each increased year of age and 6.87 points for each added comorbidity. This suggests that after 6 years, a patient is likely to have a significantly poorer outcome as compared to someone 10 years younger with 2 fewer comorbidities.

DISCUSSION

In the literature to date, very few studies have used longitudinal regression or repeated measures analysis to examine the effect of time on longterm outcomes following THR[9,10]. We found that year of followup, greater patient age at time of surgery, and greater comorbidity consistently predicted a less sustained functional outcome at mean 3.5 years of followup.

Our finding that year of followup was a significant pre-

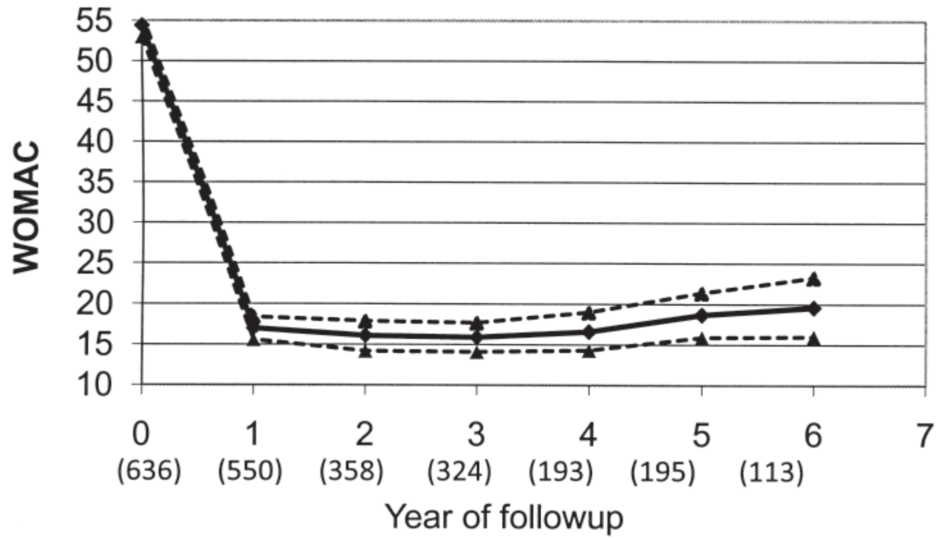

Figure 1. Western Ontario McMaster University Osteoarthritis Index scores (with 95% CI) over years of followup for patients with total hip replacement.

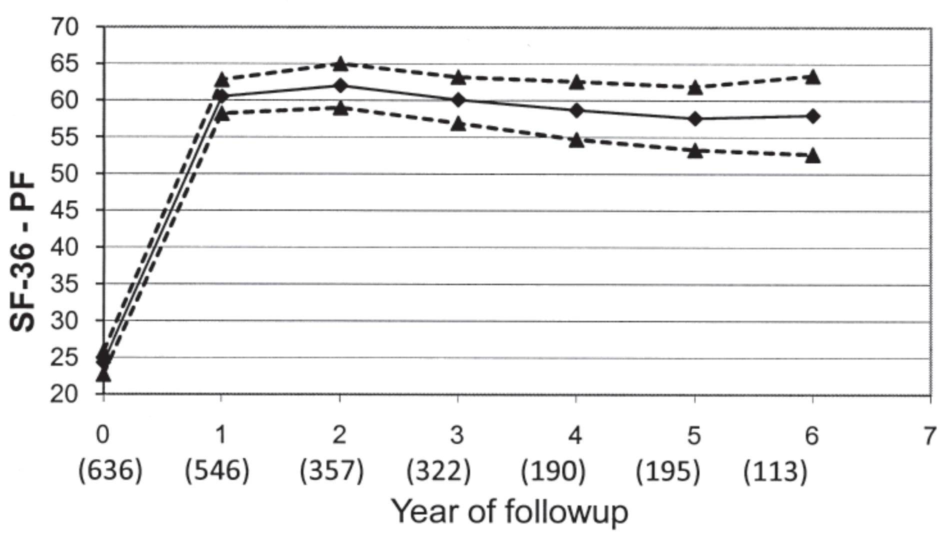

Figure 2. Medical Outcomes Study Short-Form 36 Physical Function (PF) scores (with 95% CI) over years of followup for patients with total hip replacement.

dictor of outcome independent of all patient-level demographic factors indicates that time itself is an important variable for understanding the decline in function following THR. Figure 1 shows that WOMAC scores have the greatest improvement within the first year of followup, remain relatively constant for the following 4 years, and then demonstrate gradual decline. Figures 2 and 3 (SF-36 PF and SF-36 RP) indicate a similar pattern of linear improvement, plateau, and gradual decline after about 5 years. Our results are supported by the works of others, who have shown similar results based on similar statistical analyses, with respect to SF-36 longterm outcomes following THR[9,10]. Simple linear regression would assume a straight-line relationship between baseline and last year of followup; however, our study indicates that this is not the true relationship and further lends strength to the argument for using repeated measures analysis as the statistical method for studying longterm outcomes in hip arthroplasty.

Few studies have substantiated the role of medical comorbidity as a predictor of longterm outcomes following THR. This study showed that comorbidity was a significant negative predictor with respect to WOMAC score and both SF-36 PF and SF-36 RP domains. Similar to our findings, a longterm study by Bischoff-Ferrari, *et al*, used logistic

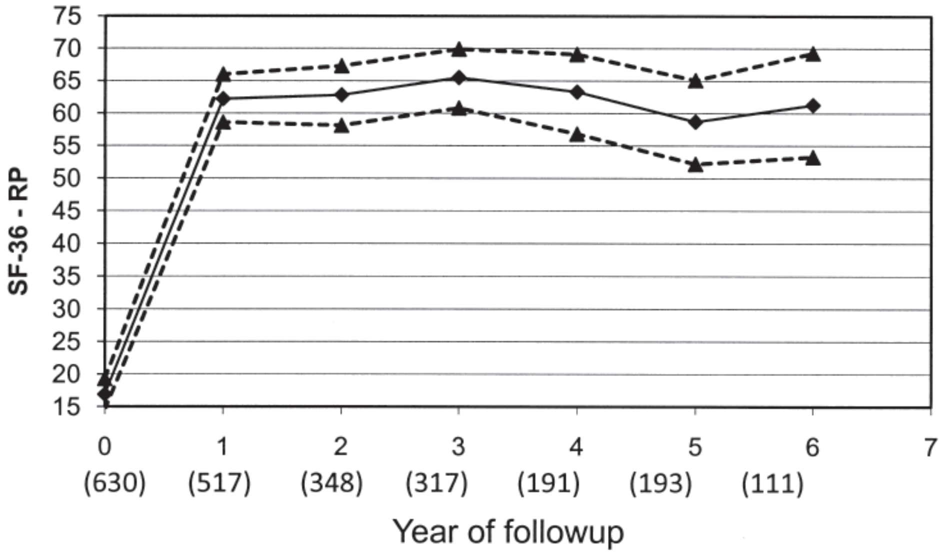

Figure 3. Medical Outcomes Study Short-form 36 Role Physical (RP) scores (with 95% CI) over years of followup for patients with total hip replacement.

Table 2. Longitudinal regression model predicting WOMAC change scores for total hip replacement at a minimum 1-year followup. Greater outcome score indicates a poorer patient outcome.

Variables	Beta Coefficient (95% CI) for Predicting WOMAC Change Score (Followup – Baseline)	p
Year of followup	0.82 (0.39, 1.24)	0.002
Age	0.25 (0.14, 0.36)	< 0.001
Male sex	1.34 (–4.39, 1.67)	0.38
BMI	–0.28 (–0.57, 0.01)	0.06
Comorbidity	2.15 (0.66, 3.14)	0.002
SF-36 Mental Health	0.04 (–0.02, 0.11)	0.22
Fixation	–0.13 (–3.89, 2.01)	0.77

WOMAC: Western Ontario McMaster University Osteoarthritis Index; BMI: body mass index; SF-36: Medical Outcomes Study Short-form 36.

Table 3. Longitudinal regression model predicting SF-36 Physical Function change scores for total hip replacement at a minimum 1-year followup. Lower outcome score indicates a poorer outcome.

Variables	Beta Coefficient (95% CI) for Predicting SF-36 Physical Function Change Scores (Followup – Baseline)	p
Year of followup	–1.61 (–2.25, –0.97)	< 0.001
Age	–0.29 (–0.44, –0.14)	0.002
Male sex	–5.18 (–9.21), –1.14)	0.012
BMI	–0.01 (–0.42, 0.39)	0.94
Comorbidity	–5.08 (–6.50, –3.67)	< 0.001
SF-36 Mental Health	0.005 (–0.09, 0.10)	0.92
Fixation	0.22 (–0.34, 1.05)	0.86

SF-36: Medical Outcomes Study Short-form 36; BMI: body mass index.

Table 4. Longitudinal regression model predicting SF-36 Role Physical change scores for total hip replacement at a minimum 1-year followup. Lower outcome score indicates a poorer outcome.

Variables	Beta Coefficient (95% CI) for Predicting SF-36 Role Physical Change Scores (Followup – Baseline)	p
Year of followup	–1.14 (–2.32, 0.03)	0.05
Age	–0.54 (–0.77, –0.31)	< 0.001
Male sex	–5.12 (–11.83, 1.58)	0.13
BMI	0.26 (–0.42, 0.95)	0.45
Comorbidity	–6.87 (–9.07, –4.66)	< 0.001
SF-36 Mental Health	0.10 (–0.05, 0.25)	0.18
Fixation	0.53 (–0.22, 1.02)	0.77

SF-36: Medical Outcomes Study Short-form 36; BMI: body mass index.

regression modeling to show that having > 2 comorbid conditions was associated with poorer function by the WOMAC scale at the 3-year followup[27]. Cushnaghan, *et al* reported on 8-year followup post-THR and found that the presence of diabetes and painful joints were the strongest predictors of outcome by SF-36 PF scores[8]. Contrary to our study, Nilsdotter, *et al* in a prospective study on THR outcomes with an average final followup of 3.6 years showed that comorbidity did not significantly predict WOMAC or SF-36 scores[7]. Similarly, an outcome study by Wood and McLauchlan with a single postoperative followup of ~10 years showed that comorbidity was predictive of SF-36 scores[28].

A number of sources in the current literature support our finding that greater age predicts poorer longterm outcome after THR[5,6,7,8]. However, our work is the first longterm account to use longitudinal regression analysis to describe this relationship as significant to both WOMAC and SF-36 outcomes.

There are potential limitations of our study. First, although we reported no revisions for aseptic loosening in our cohort, we did not examine radiographs for radiolucent lines and potential implant loosening. Second, there exists the potential for unmeasured confounders in our analysis, but we believe that based on the literature, our models have face validity. Third, it should be noted that a repeated measures analysis does not compensate for potential bias due to data lost to followup.

We identified year of followup, older age, and greater comorbidity as negative prognostic factors for a sustained functional outcome following THR. Functional results are relatively constant from years 1 to 5 following surgery and then show gradual decline. Orthopedic surgeons should appropriately counsel their patients prior to surgery to ensure realistic longterm expectations.

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