



## Insulin Dependence Increases the Risk of Failure After Total Knee Arthroplasty in Morbidly Obese Patients



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### ARTICLE INFO

#### Article history:

Received 1 July 2015

Accepted 18 August 2015

#### Keywords:

morbid obesity  
total knee arthroplasty  
diabetes  
insulin dependence  
complication

### ABSTRACT

The aims of this study were to compare the outcomes between nondiabetic ( $n = 1284$ ), type II diabetic ( $n = 530$ ), and insulin-dependent type II diabetic ( $n = 164$ ) morbidly obese (body mass index  $\geq 40$  kg/m<sup>2</sup>) patients undergoing primary total knee arthroplasty at 6-year follow-up. Patients with type II diabetes mellitus (DM) had similar outcomes when compared with non-DM patients. However, patients with insulin dependence had an increased risk of reoperation (hazard ratio [HR], 1.8;  $P = .005$ ), revision (HR, 2;  $P = .02$ ), and periprosthetic joint infection (HR, 2.1;  $P = .03$ ), as well as decreased 10-year implant survivorship (84% vs 92%;  $P = .01$ ) when compared to non-DM patients. Prospective studies should further evaluate outcomes and optimization measures within this population. Level of evidence: Level III—prognostic study.

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Patients with obesity are more likely to develop knee osteoarthritis and are more likely to require surgical intervention at a younger age [1]. Perhaps more worrisome, obese patients are more likely to experience complications after primary total knee arthroplasty (TKA), including higher rates of both septic and aseptic failure requiring revision [2,3]. In an attempt to risk stratify obese patients, many studies have correlated complications with body mass index (BMI), showing that patients with morbid obesity (BMI  $\geq 40$  kg/m<sup>2</sup>) are particularly at risk [1–6]. However, because BMI does not take body habitus or associated comorbidities into consideration, it is generally acknowledged to be a nonspecific variable [7].

Given the potential morbidity and health care burden associated with TKA in patients with morbid obesity, it is beneficial to better risk stratify patients within this demographic. Diabetes mellitus (DM) has previously been associated with increased complications and decreased implant survival rates after hip and knee arthroplasty [8–13]. However,

there are limited data to help differentiate whether diabetes and obesity are independent or additive risk factors. Furthermore, the effect of insulin dependence has not been clearly established in this population. Therefore, we sought to compare the outcomes between nondiabetic, type II diabetic, and insulin-dependent type II diabetic patients with morbid obesity after primary TKA. Specifically, we aimed to evaluate the associated risk of reoperation, revision, and periprosthetic joint infection (PJI).

### Patients and Methods

We retrospectively identified all morbidly obese patients (BMI  $\geq 40$  kg/m<sup>2</sup>) who underwent primary TKA at a single institution over a 17-year period (1995–2011) with minimum follow-up of 2 years, unless implant failure or death occurred first (1850 TKAs). Diagnosis of DM and insulin use were captured from preoperative medical clearance evaluations. Patients without DM were identified (non-DM group) and compared separately to those with type II diabetes (DM group) as well as a subgroup of insulin-dependent type 2 diabetic patients (insulin group). Patients with type I DM were excluded from the analysis (36 TKAs). Medical records, as well as our institution's total joint registry that prospectively tracks patient outcomes, were examined for details regarding complications and reoperations. Insulin dependence was noted, but hemoglobin A<sub>1c</sub> values within 3 months of surgery were only captured for 14% (250 TKAs). Therefore, this metric was not included due to the high risk of selection bias.

*Reoperation* was defined as any unplanned return to the operating room or procedure requiring a second anesthetic event (including manipulation under anesthesia). *Revision* was defined as removal and

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to <http://dx.doi.org/10.1016/j.arth.2015.08.026>.

Investigation performed at the Mayo Clinic, Rochester, MN.

The institution of all authors has received funding from Zimmer (Warsaw, IN), Stryker (Mahwah, NJ), DePuy (Warsaw, IN), and Biomet (Warsaw, IN). One or more of the authors consults for DJO Orthopedics (MJT).

Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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<http://dx.doi.org/10.1016/j.arth.2015.08.026>

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**Table 1**  
Demographics.

	Nondiabetic, No. ± SD	Diabetic, No. ± SD	Insulin Dependent, No. ± SD	P
Patients	1284	530	164	
Age (y)	63 ± 9	64 ± 8	63 ± 9	.03
Male sex	368 (29%)	186 (35%)	56 (34%)	.02
BMI (kg/m <sup>2</sup> )	44 ± 4	45 ± 5	45 ± 5	.002
Follow-up (y)	6.2 ± 3	6.3 ± 3	6.2 ± 4	.20

replacement of femoral and/or tibial components. Periprosthetic joint infections were defined using Musculoskeletal Infection Society criteria [14].

**Patients**

There were 1284 TKAs (71%) in the non-DM group and 530 (29%) TKAs in the DM group. Within the DM group, 164 TKAs (31%) were in patients with insulin dependence. There were statistical differences in regard to age, sex, follow-up time, and BMI between groups due to the large number of patients studied (Table 1). However, the clinical significance of these differences is uncertain. Mean follow-up was 6.2 years in the non-DM group (range, 2-17 years), 6.3 years in the DM group (range, 2-17 years), and 6.2 years in the insulin dependent group (range, 2-17 years) (P = .20).

**Statistical Analysis**

All outcomes were analyzed using appropriate summary statistics. For each analysis, patients in the non-DM group were compared separately to the DM and insulin groups. Baseline covariates and perioperative outcomes were compared using  $\chi^2$  tests or logistic regression (for categorical outcomes) or analysis of variance (for outcomes measured on a continuous scale) as applicable. Adverse event rates were estimated and evaluated using survivorship methods such as Kaplan-Meier estimation and Cox proportional hazards regression. Differences in survival estimates were determined using log-rank tests. All statistical tests were 2 sided, and the threshold of statistical significance was set at  $\alpha = .05$ .

**Results**

**Reoperation**

At least 1 reoperation was required for 154 patients (12%) in the non-DM group, 64 patients (12%) in the DM group (P = .94), and 33 patients (20%) in the insulin group (P = .006). The most common reasons for reoperation were infection and wound complication in all groups. Kaplan-Meier estimates for survival free of reoperation were similar between the DM and non-DM groups (P = .16, Table 2), but knees in patients with insulin dependence had worse survivor rates than

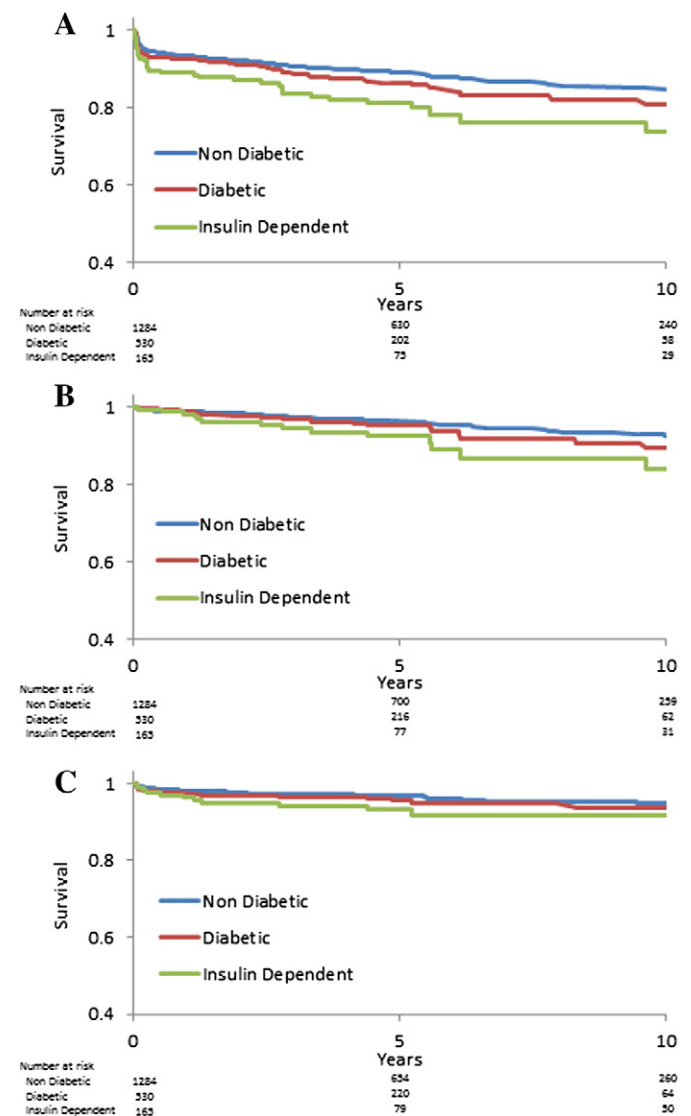
**Table 2**  
Kaplan-Meier Survival Estimates.

	1 y (% [CI])	5 y (% [CI])	10 y (% [CI])	P
Reoperation				
Nondiabetic	93 (±1)	89 (±2)	85 (±3)	
Diabetic	93 (±2)	86 (±3)	81 (±3)	.16
Insulin dependent	88 (±5)	81 (±6)	74 (±9)	.003
Revision				
Nondiabetic	99 (±1)	96 (±1)	92 (±2)	
Diabetic	99 (±1)	95 (±2)	89 (±5)	.27
Insulin dependent	98 (±2)	93 (±7)	84 (±9)	.01
Deep infection				
Nondiabetic	98 (±1)	97 (±3)	95 (±5)	
Diabetic	98 (±3)	96 (±2)	94 (±4)	.27
Insulin dependent	96 (±3)	93 (±4)	91 (±5)	.02

nondiabetic patients (74% [95% confidence interval {CI}, 65%-83%] vs 85% [95% CI, 82%-88%] at 10 years, respectively [P = .003]) (Figure). Insulin dependence was an independent risk factor for reoperation (hazard ratio [HR], 1.8 [95% CI, 1.2-2.5]; P = .005), but diabetes, sex, and age 65 years or younger were not predictive (Table 3).

**Revision**

At least 1 revision was required in 64 non-DM knees (5%), 21 DM knees (4%) (P = .38), and 15 insulin knees (9%) (P = .04). The most common reason for revision was PJI in all groups. Kaplan-Meier estimates for survival free of revision were similar between the DM and non-DM groups (P = .27; Table 2), but knees in patients with insulin dependence had worse survivor rates than nondiabetic patients (84% [95% CI, 75%-93%] vs 92% [95% CI, 90%-94%] at 10 years, respectively [P = .01]) (Figure). Insulin dependence (HR, 2.0 [95% CI, 1.1-3.4]; P = .02) and age 65 years or younger (HR, 1.6 [95% CI, 1.1-2.6]; P = .03) were predictive of revision, but diabetes and sex were not risk factors (Table 3).



**Figure.** Kaplan-Meier estimates for patient survival free of reoperation (A), revision (B), and PJI (C).

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