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ORIGINAL ARTICLE

A call to "own the bone": osteoporosis is a predictor for adverse two-year outcomes following total hip and knee arthroplasty

Alexander Chee[1] · Pelin Çeliker[1] · Kayla Basedow[1] · Mahee Islam[1] · Nayeem Baksh[1] · Neil V. Shah[1] · Ahmed M. Eldib[1] · Hassan Eldib[1] · Bassel G. Diebo[1,2] · Qais Naziri[1]

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Abstract

Purpose While bone health is instrumental in orthopedic surgery, few studies have described the long-term outcomes of osteoporosis (OP) in patients undergoing total hip (THA) or knee (TKA) arthroplasties.

Methods Using the New York State statewide planning and research cooperative system database, all patients who underwent primary TKA or THA for osteoarthritis from 2009 to 2011 with minimum 2-year follow-up were identified. They were divided based on their OP status (OP and non-OP) and 1:1 propensity score matched for age, sex, race, and Charlson/Deyo index. Cohorts were compared for demographics, hospital-related parameters, and 2-year postoperative complications and reoperations. Multivariate binary logistic regression was utilized to identify significant independent associations with 2-year medical and surgical complications and revisions.

Results A total of 11,288 TKA and 8248 THA patients were identified. OP and non-OP TKA patients incurred comparable overall hospital charges for their surgical visit and hospital length of stay (LOS) (both, $p \geq 0.125$). Though OP and non-OP THA patients incurred similar mean hospital charges for their surgical visit, they experienced longer hospital LOS (4.3 vs. 4.1 days, $p = 0.035$). For both TKA and THA, OP patients had higher rates of overall and individual medical and surgical complications (all, $p < 0.05$). OP was independently associated with the 2-year occurrence of any overall, surgical, and medical complications, and any revision in TKA and THA patients (all, OR ≥ 1.42, $p < 0.001$).

Conclusion Our study found OP was associated with a greater risk of 2-year adverse outcomes following TKA or THA, including medical, surgical, and overall complications as well as revision operations compared to non-OP patients.

Keywords Own the bone · Osteoporosis · Total knee arthroplasty · Total hip arthroplasty · Bone health

Introduction

Osteoporosis (OP) is an aging metabolic disease that is characterized by low bone mineral density (BMD) stemming from altered microarchitecture, poor intrinsic properties, defective microdamage repair, and increased remodeling of bone [1]. It is a condition that leads to increased bone fragility, as noted by the higher fracture risk in affected individuals [2]. Although it affects 30% and 12% of all women and men, respectively, these numbers are only projected to rise as the population ages [1].

Osteoarthritis (OA) is a degenerative disease characterized by synovial inflammation and progressive loss of the articular cartilage [3]. In particular, hip and knee OA are the most common subtypes. Knee OA symptomatically affects 10% and 13% of men and women above the age of 60 years, respectively [4]. The prevalence of symptomatic hip OA is reported to be 9.5% in adults age 45 years and older in the USA [5]. Patients often experience recurrent pain, as well as joint stiffness and instability [6]. Total knee (TKA) and total hip (THA) arthroplasties are two of the most common and successful surgical procedures for the management of symptomatic lower extremity OA. Over 600,000 TKAs were performed in 2010 in the USA; this number is projected to reach 3.48 million annually by the year 2030 [7, 8]. Furthermore,

✉ Qais Naziri
qnaziri@gmail.com

[1] Department of Orthopaedic Surgery and Rehabilitation Medicine, The State University of New York Downstate Health Sciences University, 450 Clarkson Ave, MSC 30, Brooklyn, NY 11203, USA

[2] Department of Orthopaedic Surgery, Warren Alpert School of Medicine, Brown University, Providence, RI, USA

the number of THAs performed each year is projected to reach 572,000 by the year 2030, a 174% increase compared to the THA rate in 2005 [8]. It was previously believed that OP protected against OA, and subsequently primary TJA, since osteoporotic bone could absorb loads more effectively and reduce the amount of stress placed on joint cartilage [9]. However, it is now known that these conditions are not mutually exclusive [10].

OP in patients undergoing total joint arthroplasties (TJAs) is underdiagnosed and undertreated. Studies have shown that up to 25% of TJA patients meet the criteria for OP but only 5% receive pre- or postoperative therapy [11]. Osteoporotic patients undergoing THA have higher risk for perioperative fracture, periprosthetic fracture, late aseptic loosening, poor stability, and delayed osseointegration [10, 12]. However, little is known about the outcomes of TKA in patients with OP. For both TKA and THA, there are no large studies investigating the effect of OP on postoperative outcomes. The purpose of this study was to analyze the effect of OP on patients undergoing TKA and THA, by evaluating the two-year postoperative complication and reoperation rates.

Materials and methods

Data source

This study retrospectively queried the New York statewide planning and research cooperative system (SPARCS), an all-payer database that is managed by the New York State (NYS) Department of Health. Established in 1979, this database records patient demographics, diagnoses, treatments, services, and charges for all non-federal hospital discharge, ambulatory surgical case, and emergency department visit in NYS. All inpatient data are submitted in a single designated format and schedule per state regulations.

Study subjects

All patients who underwent a TKA or THA between 2009 and 2011 with a minimum two-year follow-up were identified using international classification of diseases (ICD)-9 codes. Excluded were individuals with bone mineralization disorders other than OP (osteomalacia, rickets, hyperparathyroidism [primary, secondary, tertiary], vitamin D deficiency), systemic (fibrous dysplasia, sickle cell disease, renal osteodystrophy) and endocrine disorders (thyroid hypo- or hyperfunctioning disorders, adrenal insufficiency, adrenal hyperplastic syndromes) affecting bone quality or production, as well as patients with surgical indications of trauma, systemic disease, infection, or cancer/metastatic disease. Included TKA or THA patients were divided into two cohorts based on the presence (OP) or absence (non-OP) and were placed into respective cohorts. Both groups were 1:1 propensity score matched for age, sex, race, and Charlson/Deyo index.

Outcome measures

All medical and surgical complications, as well as revision surgeries, within two years after the primary TKA or THA were evaluated and recorded. Medical complications included any systemic or wound-related complications that were non-surgical in nature. Surgical complications included implant-related surgical complications, and any systemic complication that required surgery for treatment. Matched cohorts were analyzed for demographics, hospital-related parameters, and any two-year postoperative complication or reoperation. Multivariate binary logistic regression was used to identify independent predictors of revisions, as well as two-year medical and surgical complications. Covariates encompassed OP, body mass index (BMI), sex, race, primary insurance/payer, and Charlson/Deyo index. All statistical analyses were performed with SPSS version 26 (IBM Corp., Armonk, NY, USA), using a p value <0.05 as threshold for statistical significance.

Results

A total of 11,288 TKA patients were identified, half ($n=5644$ [50%]) of whom had OP. No significant differences were detected between OP and non-OP cohorts in terms of mean age, mean Charlson/Deyo index, and sex (Table 1). Race (White: 75.9% [OP] vs. 72.4% [non-OP]) and primary insurer (Medicare: 73.3 vs. 70.3%) differed significantly between groups (both, $p<0.001$). Patients with OP undergoing TKA incurred similar mean hospital charges ($44,331 vs. $44,795, $p=0.327$) and lengths of stay (3.9 days vs 3.8 days, $p=0.125$) compared to patients without OP (Table 1).

A total of 8,248 THA patients were identified, half ($n=4124$ [50%]) of whom had OP. There was no significant difference between OP and non-OP in terms of mean age, mean Charlson/Deyo Index Score, and sex (Table 2). Race (White: 84.7% [OP] vs. 82.9% [non-OP]) and primary insurer (Medicare: 73.4 vs. 69.5%) differed significantly between both groups (both, $p<0.001$). Length of stay (4.3 days vs. 4.1 days) also differed significantly between the two groups ($p=0.035$). Patients with OP who underwent THA incurred similar mean hospital charges ($48,573 vs $49,400, $p=0.244$) compared to those without OP (Table 2).

Patients with OP who underwent TKA experienced higher two-year rates of overall complications (26.0 vs. 18.1%), and revisions (18.6 vs. 13.8%) compared to non-OP individuals (all, $p<0.001$). Overall medical (21.4 vs.

Table 1 Patient demographics and hospital-related parameters stratified by diagnosis of osteoporosis (OP) in patients undergoing total knee arthroplasty

	OP	non-OP	*p* value
Number of patients	5644	5644	–
Mean age	71.8	71.5	0.208
Mean Charlson/Deyo index	0.62	0.61	0.232
Sex			
Female	93.2%	93.0%	0.711
Male	7.8%	7.0%	
Race			
White	75.9%	72.4%	**< 0.001**
Black	6.5%	10.8%	
Primary insurance			
Medicare	73.3%	70.3%	**< 0.001**
Medicaid	4.4%	3.7%	
Private insurance	18.9%	22.0%	
Self-pay	0.4%	0.5%	
No charge	0.0%	0.0%	
Other	3.0%	3.4%	
Mean hospital charge	$44,331	$44,795	0.327
Mean length of hospital stay	3.9 days	3.8 days	0.125

OP: Osteoporosis

Table 2 Patient demographics and hospital-related parameters stratified by diagnosis of osteoporosis (OP) in patients undergoing total hip arthroplasty

	OP	non-OP	*p* value
Number of patients	4124	4124	–
Mean age	72.24	71.82	0.070
Mean Charlson/Deyo index	0.62	0.59	0.084
Sex			
Female	89.0%	89.8%	0.283
Male	11.0%	10.2%	
Race			
White	84.70%	82.90%	**< 0.001**
Black	4.30%	7.10%	
Primary insurance			
Medicare	73.4%	69.5%	**< 0.001**
Medicaid	2.9%	2.3%	
Private insurance	21.2%	25.8%	
Self-pay	0.6%	0.4%	
No charge	0.0%	0.0%	
Other	2.0%	1.9%	
Mean hospital charge	$48,573	$49,400	0.244
Mean length of hospital stay	4.3 days	4.1 days	**0.035**

OP: Osteoporosis

15.2%) and surgical (9.5 vs. 5.8%) complications were also more common in OP patients (both, $p < 0.001$). Individual medical complications were more commonly encountered in patients with OP, and included acute renal failure (6.6vs. 4.5%), pneumonia (5.1 vs. 3.1%), deep vein thrombosis (3.3 vs. 2.6%), sepsis (3.4 vs. 2.3%), infection (2.6 vs. 1.6%), and pulmonary embolism (1.1 vs. 0.7%) (Fig. 1, all, $p \leq 0.029$). Individual surgical complications, including implant-related complications (5.9 vs. 3.3%), wound infections (3.0 vs. 1.9%), and implant infections (2.1 vs. 1.1%), were also more prevalent in osteoporotic TKA patients (all, $p < 0.001$).

Patients with OP who underwent THA experienced significantly higher two-year overall complication (30.4 vs 20.3%) and revision (12.5 vs. 9.2%) rates compared to non-OP individuals (all, $p < 0.001$). Overall medical (23.0 vs. 16.3%, $p < 0.001$) complications were more commonly seen in osteoporotic patients. These included: acute renal failure (7.5 vs. 5.5%), pneumonia (7.0 vs. 4.1%), deep vein thrombosis (3.3 vs. 1.8%), and sepsis (4.2 vs 2.4%) (Fig. 2, all, $p \leq 0.001$). Surgical complications (13.1 vs. 7.3%) were also more prevalent in patients with OP undergoing THA ($p < 0.001$) and included implant-related complications (5.8 vs. 2.7%), wound infections (2.4 vs. 1.6%), and implant infections (1.6 vs. 1.0%) (all, $p \leq 0.009$).

In patients undergoing TKA, multivariate binary logistic regression revealed that baseline OP was independently associated with two-year occurrences of any medical complication (OR = 1.52, 95% Confidence Interval [CI] 1.38–1.68), any surgical complication (OR = 1.75, 95% CI 1.51–2.02), any overall complication (OR = 1.61, 95% CI 1.47–1.77), and any revision (OR = 1.42, 95% CI 1.28–1.58) (all, $p < 0.001$). For patients undergoing THA, it was revealed that OP was independently associated with any medical complication (OR = 1.51, 95% CI 1.35–1.69), any surgical complication (OR = 1.95, 95% CI 1.51–2.51), any overall complication (OR = 1.70, 95% CI 1.53–1.88), and any revision (OR = 1.44, 95% CI 1.25–1.66) (all, $p < 0.001$).

Discussion

This study sought to determine the impact of osteoporosis on adverse outcomes, including complications and revision surgery, in patients who underwent TKA or THA. To our knowledge, it is the first such study to utilize a large representative database to determine these outcomes.

The prevalence of OP is often underestimated in patients undergoing total joint arthroplasty (TJA) by approximately 25% [11]. Therefore, many TJA patients, namely TKA and THA, have undiagnosed and therefore untreated OP. With the number of annual TKAs and THAs expected to rise substantially in the next 10 years, it becomes increasingly

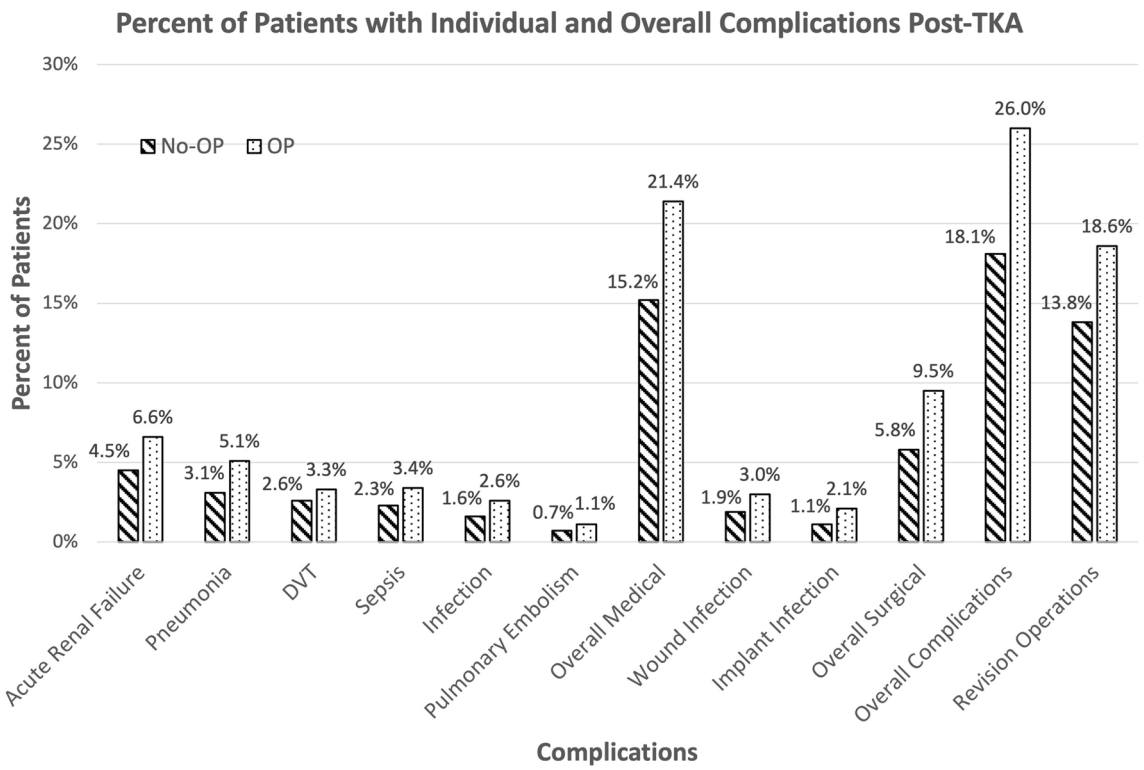

Fig. 1 Proportion of osteoporotic (OP) and non-osteoporotic (non-OP) patients with individual and overall complications post-total knee (TKA)

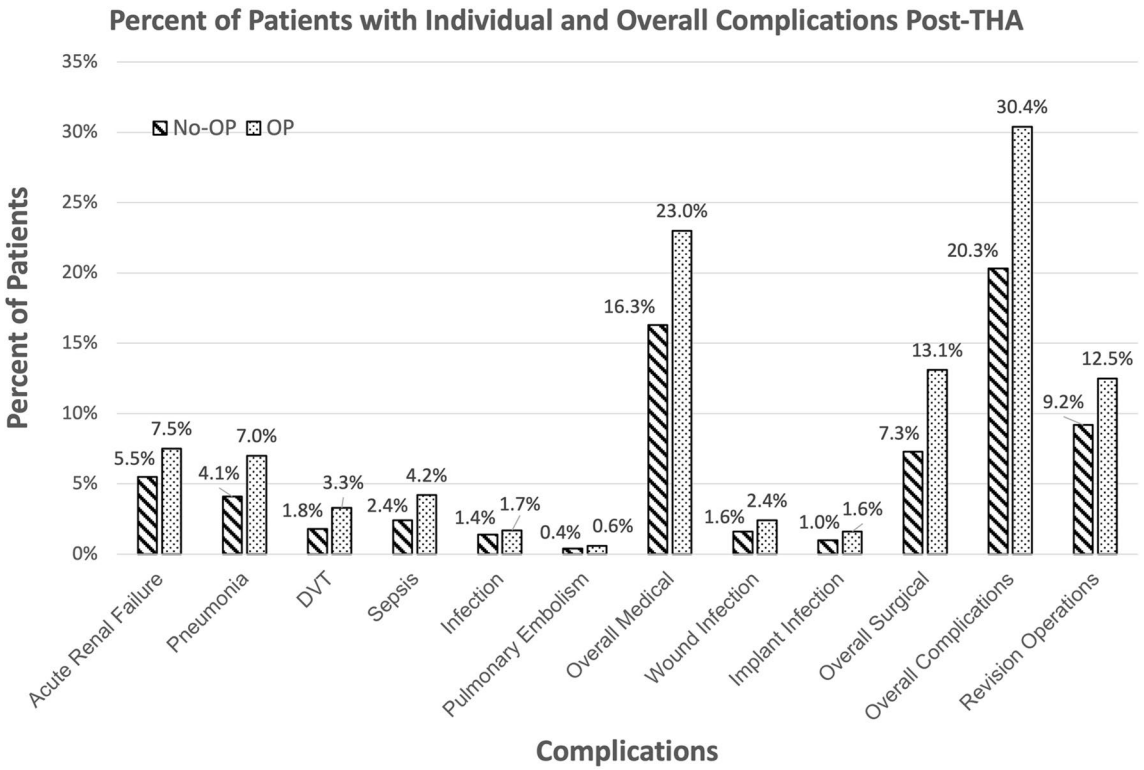

Fig. 2 Proportion of osteoporotic (OP) and non-osteoporotic (non-OP) patients with individual and overall complications post-total hip (THA)

important to understand what factors affect patient outcomes and what can be done to mitigate adverse events [8].

The present study showed that OP is independently associated with worse two-year outcomes following TJA. Patients with OP had significantly higher rates of revision, individual surgical and medical complications even after adjusting for patient demographics (BMI, age, race, and comorbidity scores). In 2010, 55,000 revision knee arthroplasties were performed, which is projected to rise fivefold by 2030 with an economic burden exceeding $13 billion [13]. Similarly, the economic burden of revision THA was $3.8 billion in 2015 [14]. It is therefore important to understand what factors increase the odds of revision.

While there is limited literature on the impacts of OP on postoperative outcomes after THA and TKA, multiple authors have sought to determine the impact of bisphosphonates on THA and TKA patients. It has been previously shown that postoperative OP treatment leads to better outcomes after TKA implying a relationship between OP status and TKA. Indeed, Teng et al. [15] performed a meta-analysis investigating the association between bisphosphonate use and the risk of implant revision after THA and TKA. The authors found that patients who used postoperative bisphosphonates for at least six months had significantly lower (50%) risks of implant revision after THA or TKA. Similarly, Prieto-Alhambra et al. [16] found that bisphosphonate use in patients after TKA or THA for at least six months was associated with a significantly longer implant survival and almost twofold increase in time to revision surgery. Another study by Namba et al. [17] showed that OP and osteopenic TKA patients on postoperative bisphosphonates were significantly less likely to have a revision for any reason or an aseptic revision compared to subjects not receiving this drug. Finally, Ro et al. utilized a large retrospective database and demonstrated a lower revision rate for THA and TKA among patients taking bisphosphonates postoperatively as well as an association between bisphosphonate use for over a year and a further reduction in revisions [18]. It is unclear whether this effect is due to bisphosphonates themselves, or it underscores the substantial underdiagnosis of OP. Further prospective research is warranted to determine the effects of bisphosphonates on arthroplasty outcomes among patients with OP.

In contrast, other studies have found different outcomes in OP patients undergoing TKA. Huang et al. [19] compared TKA outcomes and BMD in 43 postmenopausal women and found that lower bone quality was associated with less postoperative pain and higher subjective ratings of functional outcomes. However, their follow-up period was limited to six months, which was insufficient enough to determine true long-term outcomes. Similarly, Watanabe et al. assessed TKA patients' prognosis and identified that the severity of OP had no correlation with knee function scores; they concluded that OP, counterintuitively, does not negatively impact TKA outcomes in the elderly population [20]. Khatod et al. compared THA outcomes with bisphosphonate use and found that adjusted risk for periprosthetic fracture was slightly higher in the patients on bisphosphonates. However, when stratified by age, there was no difference in fracture rates for patients older than 65 years [21].

Prior research has shown that lower BMD is associated with higher fracture risk [22]. The present study demonstrates an association between low BMD and postoperative complications in patients undergoing arthroplasty. It has been demonstrated that BMD declines substantially one-year post-TKA in comparison to baseline status [23]. In patients who have undergone THA, significant BMD loss has been demonstrated in patients five years postoperatively despite improvements in physical activity [24]. Thus, the low BMD found in patients with OP may be exacerbated by TJA. In prior studies, OP patients exhibited a higher risk of perioperative complications including fracture, implant migration, and aseptic loosening, following lower extremity arthroplasty [10, 11, 25]. Our findings add to the results of the aforementioned studies by highlighting the association of OP with individual and overall medical and surgical complications, as well as revision procedures among patients undergoing TKA and THA.

This study has a number of limitations. Its retrospective nature limits the number of the variables collected to the ones initially coded within the SPARCS database. Indeed, some entries of particular interest that could not be evaluated include surgical factors such as estimated blood loss, type of anesthesia, or case complexity and medical factors such as preoperative hemoglobin level and serum albumin level. Additionally, utilizing ICD-9 coding is dependent on coders and there may be heterogeneity in the way certain diagnoses are recorded. We also acknowledge that our study utilizes a follow-up period (two years) that may need to be extended in order to adequately stratify outcomes over a longer time period, which would lead to more accurate statistical analysis of revisions and reoperations. Compared to most current studies, which utilize subjective functional indicators for short-term outcomes, our analysis used objective and well-defined ICD-9 codes from a large database that allows for long-term follow-up. In addition, our results were not limited to functional outcomes, as overall (general) and individual (specific) complications were evaluated. Finally, although originating from a single state, this study employed a large sample size from a diverse patient group, allowing for the generalizability of its results. Nonetheless, our study provides valuable information regarding TJA outcomes in patients with OP. Further studies may help determine methods in which these patients be best optimized for surgery to ensure the best possible outcomes.

Conclusion

Patients with OP undergoing THA and TKA may experience significantly higher risk of complications and revisions rates than those without OP. This study should serve as a call to orthopedic surgeons to optimize preoperative screening for and stratification of OP and other metabolic bone disorders prior to operative procedures such as TKA and THA. More research investigating the relationship between perioperative OP treatment in patients undergoing orthopedic surgery, namely lower extremity TJA, is warranted.

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Declarations

Conflicts of interest No author has any conflict of interest to report.

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