

Predictive value of bone mineral density assessment methods for postoperative complications after unicompartmental knee arthroplasty

Jichao Bian

Affiliated Hospital of Jining Medical University

Yongqi Xia

Jining Medical University

Wenbo Meng

Jining Medical University

Jiahao Liang

Jining Medical University

Haoyu Liu

Jining Medical University

Long Yuan

Affiliated Hospital of Jining Medical University

Shuyu Yue

Jining Medical University

Xiaowei Zhao

Affiliated Hospital of Jining Medical University

Yuanmin Zhang

Affiliated Hospital of Jining Medical University

Guodong Wang

15106722107@163.com

Affiliated Hospital of Jining Medical University

Research Article

Keywords: unicompartmental knee arthroplasty, bone mineral density, quantitative computed tomography, postoperative complications, propensity score matching, risk prediction

Posted Date: August 27th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10443989/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Predictive value of bone mineral density assessment methods for postoperative complications after unicompartmental knee arthroplasty

Jichao Bian^{1†}, Yongqi Xia^{2†}, Wenbo Meng², Jiahao Liang², Haoyu Liu², Long Yuan¹, Shuyu Yue², Xiaowei Zhao¹, Yuanmin Zhang¹ and Guodong Wang^{1*}

¹Department of Joint and Sports Medicine, The Affiliated Hospital of Jining Medical University, Jining, People's Republic of China

²School of Clinical Medicine, Jining Medical University, Jining, People's Republic of China

[†]These authors contributed equally to this work.

*Correspondence:

Guodong Wang

15106722107@163.com

All the authors' emails:

Jichao Bian: bjc0629@163.com

Yongqi Xia: 15098900586@163.com

Wenbo Meng: 15653805944@163.com

Jiahao Liang: ljh771246300@163.com

Haoyu Liu: 363626318@qq.com

Long Yuan: yuanlong365@163.com

Shuyu Yue: 750611206@qq.com

Xiaowei Zhao: 18678766708@163.com

Yuanmin Zhang: ZYMJN@sina.com

Guodong Wang: 15106722107@163.com

Abstract

Objective To investigate the predictive value of preoperative bone mineral density (BMD) measurements for postoperative complications and reoperation risk in patients undergoing unicompartmental knee arthroplasty (UKA).

Methods A total of 1,945 patients with knee osteoarthritis (KOA) who underwent primary

UKA at the Affiliated Hospital of Jining Medical University between November 2018 and November 2025 were retrospectively included. Preoperative lumbar spine BMD was measured using quantitative computed tomography. Patients were divided into a reduced BMD group ($< 80 \text{ mg/cm}^3$) and a normal BMD group ($\geq 80 \text{ mg/cm}^3$). Data on demographics, surgical parameters, and outcomes were collected. Propensity score matching was performed to balance confounding variables. Univariate and multivariate logistic regression analyses were conducted to identify independent risk factors for postoperative complications, and receiver operating characteristic curves were plotted to evaluate the predictive efficacy of BMD.

Results Among the enrolled patients, 234 (12.03%) were in the reduced BMD group and 1,711 (87.97%) in the normal BMD group, with the former having a higher proportion of women patients and a higher age ($P < 0.001$). After 1:1 propensity score matching, 233 patients remained in each group. The reoperation rate was significantly higher in the reduced BMD group (3.00% vs. 0.43%, $P = 0.032$). Patients with complications had a significantly lower median lumbar BMD value compared with those without complications (93.3 vs. 103.2 mg/cm^3 , $P = 0.026$). Multivariate logistic regression analysis confirmed that lumbar BMD was an independent negative predictor of complications after UKA ($OR = 0.700$, $P = 0.007$); lower BMD values were associated with higher risks of postoperative complications.

Conclusions Preoperative decreased BMD is an independent risk factor for postoperative complications and reoperation after UKA. Routine preoperative BMD screening and optimized perioperative bone health management should be implemented to reduce complications and improve surgical outcomes.

Keywords: unicompartmental knee arthroplasty, bone mineral density, quantitative computed tomography, postoperative complications, propensity score matching, risk prediction

Introduction

Unicompartmental knee arthroplasty (UKA) is a widely accepted knee-preserving procedure for end-stage osteoarthritis confined to the medial knee compartment. Compared to total knee arthroplasty (TKA), UKA exhibits multiple advantages including reduced surgical trauma, preservation of native knee structures, faster postoperative rehabilitation, and superior patient-reported outcomes, contributing to its increasing clinical popularity [1-3]. Although the overall incidence of postoperative complications after UKA is lower than that of TKA, adverse events such as prosthetic loosening, surgical site infection, thromboembolism, and bearing dislocation still occur in clinical practice. A subset of patients ultimately require reoperation, which significantly compromises surgical efficacy and long-term functional

prognosis [4-6]. Currently, the prevention and management of complications following UKA primarily depend on standardized surgical techniques and routine perioperative care, while precise risk prediction and individualized early warning systems for postoperative adverse events remain underdeveloped [7].

Osteopenia and osteoporosis are highly prevalent comorbidities among elderly patients with knee osteoarthritis (KOA). These conditions are characterized by reduced bone mass, deteriorated bone microarchitecture, and impaired biomechanical properties of bone [8]. Recent evidence increasingly demonstrates that abnormal BMD is strongly associated with adverse outcomes following joint arthroplasty. Preoperative osteoporosis significantly increases the risks of postoperative complications, hospital readmission, and revision surgery in patients undergoing TKA [9-11]. BMD directly reflects the fixation strength at the bone-prosthesis interface and the skeleton's resistance to mechanical injury, making it a critical determinant of postoperative rehabilitation after orthopedic surgery [12]. However, quantitative analyses examining the relationship between BMD values and the risks of postoperative complications and reoperation are limited, particularly in the context of UKA, and the predictive value of preoperative BMD measurement for postoperative risk stratification after UKA has not been systematically validated [13].

In light of the aforementioned research gaps, this large-scale retrospective cohort study collected clinical data from 1,945 patients who underwent UKA. Preoperative bone health was quantitatively assessed using lumbar BMD measurements derived from quantitative computed tomography (QCT). Propensity score matching (PSM) was employed to balance baseline confounding variables. This study aimed to evaluate the predictive value of preoperative BMD for postoperative complications and reoperation risk following UKA, establish a simple and efficient preoperative risk assessment marker, and provide scientific evidence to support precise, individualized perioperative management for patients undergoing UKA.

Materials and methods

Study population

A total of 1,945 patients diagnosed with KOA who underwent primary medial compartment UKA at the Department of Orthopaedics, Affiliated Hospital of Jining Medical University, from November 2018 to November 2025 were retrospectively enrolled in this study. The cohort included 676 men (34.76%) and 1,269 women (65.24%). This study was approved by the Ethics Committee of the Affiliated Hospital of Jining Medical University (Ethics Approval No. 2023C116). All patients provided written informed consent prior to surgery,

and all study procedures were conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki.

Inclusion criteria

Patients diagnosed with end-stage medial compartment KOA based on clinical manifestations, physical examination, X-ray, and MRI imaging, who have undergone ineffective conservative treatment for at least six months.

Knee flexion contracture deformity $< 5^{\circ}$, varus deformity $< 15^{\circ}$, preoperative knee range of motion $\geq 90^{\circ}$, and intact medial collateral ligament function.

Age ≥ 50 years and undergoing primary UKA for the first time.

Complete clinical and surgical data, along with follow-up information, and availability for preoperative examinations and postoperative follow-up visits.

Exclusion criteria

History of knee trauma or previous knee arthroscopy.

Preoperative complications include severe systemic diseases such as deep vein thrombosis (DVT) of the lower extremities, uncontrolled infections, immunodeficiency disorders, cardiac and cerebrovascular dysfunctions, among others.

Presence of psychiatric disorders or cognitive impairment, accompanied by poor compliance with follow-up.

Known allergy to routine perioperative medications.

Complicated by severe rheumatoid arthritis, metabolic bone diseases, or other disorders affecting knee function and bone metabolism.

Methods

Collection of Baseline Data: Demographic data, including age, sex, height, and body weight, were uniformly collected to calculate BMI. Medical histories of underlying comorbidities were recorded, such as hypertension, diabetes mellitus, coronary heart disease, and cerebral infarction. Diagnoses of related diseases were made in strict accordance with clinical criteria: anemia was defined as fasting hemoglobin (Hb) < 120 g/L in men and < 110 g/L in women; type 2 diabetes mellitus was diagnosed if fasting blood glucose was ≥ 7.0 mmol/L or if patients had a prior confirmed diagnosis; hypertension was defined as systolic blood pressure

≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, or long-term regular use of antihypertensive medication [14-16].

BMD Measurement Protocol: Preoperative lumbar spine (T11–L4) BMD testing was conducted using QCT in the hospital's dedicated BMD examination room for all participants. Patients were positioned supine, with all metallic foreign objects removed from the body surface prior to the standard scan. The system automatically calculated bone mineral content, absolute BMD values, T-scores, and Z-scores. Patients were stratified based on measured BMD values as follows: normal BMD (≥ 120 mg/cm³), osteopenia (80–120 mg/cm³), and osteoporosis (< 80 mg/cm³). All patients with BMD < 80 mg/cm³ were assigned to the reduced BMD group, while those with BMD ≥ 80 mg/cm³ comprised the non-reduced BMD group [17].

Collection of Surgical and Postoperative Outcome Indicators: Intraoperative parameters, including operative duration, estimated blood loss, anesthesia modality, and Hb levels preoperatively as well as on postoperative days 1 and 3, were documented, along with the length of hospital stay. All patients were followed for three months postoperatively. The primary adverse events monitored included severe postoperative pain (visual analogue scale [VAS] score ≥ 7), prosthetic loosening, prosthetic migration, bearing dislocation, surgical site infection, DVT, and pulmonary embolism (PE). Readmissions, reoperations, and the timing of secondary surgeries were also recorded. DVT was confirmed by lower-extremity venous ultrasonography performed 3–7 days after surgery. Surgical site infection and periprosthetic joint infection (PJI) were diagnosed according to the 2018 prosthetic infection criteria and the 2014 expert consensus on PJI. PE was comprehensively diagnosed based on clinical manifestations, D-dimer levels, and computed tomography angiography (CTA) of the thorax [18,19].

Statistical analysis

Statistical analyses were performed using R software, version 4.1.1. Normally distributed continuous variables were presented as mean $\pm$ standard deviation and compared between groups using the independent Student's t-test. Non-normally distributed continuous variables were expressed as median (interquartile range), with intergroup comparisons conducted using the Mann–Whitney U test. Categorical variables were reported as counts (percentages) and compared using the χ^2 test.

A 1:1 PSM algorithm with a caliper width of 0.2 was applied to minimize bias caused by baseline intergroup confounding variables. Matching covariates included sex, age, comorbidities, and surgical parameters. Univariate and multivariate logistic regression models

were constructed to identify independent risk factors for postoperative complications, using a variable entry threshold of $P < 0.1$. Receiver operating characteristic (ROC) curves were generated to calculate the area under the curve (AUC) to evaluate the predictive performance of BMD values. A two-tailed $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics of patients

A total of 1,945 patients undergoing UKA with complete follow-up data were enrolled in this study, including 234 patients (12.03%) in the BMD reduction group and 1,711 patients (87.97%) in the non-reduction group. Baseline analyses revealed statistically significant differences between groups in gender and age distribution ($P < 0.001$). The proportion of woman patients (84.62%) and the mean age (66.41 ± 7.22 years) in the BMD reduction group were significantly higher than those in the non-reduction group. No significant difference in body mass index (BMI) was observed between the two groups ($P = 0.818$). BMD was significantly negatively correlated with age ($r = -0.168$, $P < 0.001$), whereas no significant correlation was found between BMD and BMI ($r = 0.019$, $P = 0.389$). The results were summarized in Table 1.

Table 1 Comparison of baseline characteristics between the two patient groups

Baseline indicators	Reduced BMD group (n=234)	Normal BMD group (n=1,711)	t/χ^2 value	P-value
Gender [n (%)]			44.02	<0.001
Man	36(15.38)	640(37.41)		
Woman	198(84.62)	1071(62.59)		
Age (years, $\bar{x} \pm s$)	66.41 $\pm$ 7.22	62.86 $\pm$ 7.68	6.69	<0.001
BMI (kg/m ² , $\bar{x} \pm s$)	26.65 $\pm$ 3.39	26.71 $\pm$ 3.76	-0.23	0.818

Comparison of intraoperative and hospitalization-related indicators between the two groups

The results demonstrated that the group with reduced BMD had a shorter operative time, lower preoperative and postoperative Hb levels, and a higher prevalence of underlying comorbidities, including hypertension, coronary heart disease, cerebral infarction, and diabetes mellitus. All intergroup differences were statistically significant ($P < 0.05$). No statistically significant differences were observed between the two groups regarding

intraoperative blood loss and length of hospital stay ($P > 0.05$). Detailed data were presented in Table 2.

Table 2 Intraoperative and hospitalization-related indicators of patients in the two groups

Influencing factors	Normal BMD group	Reduced BMD group	<i>P</i> -value
Operative time (min, $\bar{x} \pm s$)	65.14±18.04	61.38±14.8	0.002
Intraoperative blood loss (mL, $\bar{x} \pm s$)	28.52±11.69	27.78±10.23	0.356
Anesthesia modality [n (%)]			<0.001
Local anesthesia	44(2.57)	16(6.84)	
General anesthesia	1667(97.43)	218(93.16)	
Preoperative hemoglobin (Hb, g/L, $\bar{x} \pm s$)	139.01±13.96	135.44±11.96	<0.001
Postoperative day 1 Hb (g/L, $\bar{x} \pm s$)	127.5±12.74	123.77±10.92	<0.001
Postoperative day 3 Hb (g/L, $\bar{x} \pm s$)	122.17±13.17	119.11±11.7	0.001
Length of hospital stay (d, $\bar{x} \pm s$)	7.4±2.75	7.4±2.19	0.979
History of hypertension [n (%)]	657(38.4)	107(45.73)	0.031
History of coronary heart disease [n (%)]	202(11.81)	45(19.23)	0.001
History of cerebral infarction [n (%)]	131(7.66)	29(12.39)	0.013
History of diabetes mellitus [n (%)]	214(12.51)	43(18.38)	0.013

Balance analysis of baseline characteristics after PSM

To eliminate confounding biases arising from comorbidities and demographic characteristics, 1:1 PSM was performed, resulting in 233 patients enrolled in each group after matching. No

statistically significant differences were observed between the groups in baseline variables, including gender, age, operative time, intraoperative blood loss, Hb levels, length of hospital stay, and the prevalence of all types of underlying comorbidities ($P > 0.05$). The baseline characteristics were well balanced and comparable between the two groups, supporting subsequent outcome analyses. Detailed data were presented in Table 3.

Table 3 Balance analysis of baseline characteristics between the two groups after 1:1 PSM

Influencing factors	Normal BMD reduction group	Reduced BMD group	<i>P</i> -value
Gender [n (%)]			0.509
Man	31(13.3)	36(15.45)	
Woman	202(86.7)	197(84.55)	
Age (years, $\bar{x} \pm s$)	66.19 $\pm$ 7.1	66.37 $\pm$ 7.2	0.791
Operative time (min, $\bar{x} \pm s$)	62.05 $\pm$ 19.42	61.44 $\pm$ 14.81	0.703
Intraoperative blood loss (mL, $\bar{x} \pm s$)	27.85 $\pm$ 11.44	27.79 $\pm$ 10.25	0.949
Preoperative hemoglobin (Hb, g/L, $\bar{x} \pm s$)	134.84 $\pm$ 12.05	135.42 $\pm$ 11.98	0.606
Postoperative day 1 Hb (g/L, $\bar{x} \pm s$)	123.25 $\pm$ 11.62	123.79 $\pm$ 10.94	0.602
Postoperative day 3 Hb (g/L, $\bar{x} \pm s$)	118.48 $\pm$ 12.59	119.06 $\pm$ 11.69	0.612
Length of hospital stay (d, $\bar{x} \pm s$)	7.17 $\pm$ 1.78	7.41 $\pm$ 2.19	0.203
Preoperative flexion range ($^{\circ}$, $\bar{x} \pm s$)	101.69 $\pm$ 10.2	101.79 $\pm$ 11.81	0.925
Preoperative extension lag ($^{\circ}$, $\bar{x} \pm s$)	4.58 $\pm$ 3.81	5.27 $\pm$ 6.2	0.147
History of hypertension [n (%)]	103(44.21)	106(45.49)	0.780

Influencing factors	Normal BMD reduction group	Reduced BMD group	P-value
History of coronary heart disease [n (%)]	40(17.17)	45(19.31)	0.549
History of cerebral infarction [n (%)]	25(10.73)	28(12.02)	0.662
History of diabetes mellitus [n (%)]	42(18.03)	42(18.03)	1.000

Comparison of postoperative complications and reoperation rates between the two groups

Before PSM, there were no statistically significant differences in the incidence of postoperative complications or reoperation rates between the two groups ($P > 0.05$). After balancing confounding factors using PSM, the reoperation rate was significantly higher in the BMD reduction group compared to the non-reduction group (3.00% vs. 0.43%, $P = 0.032$), indicating a statistically significant intergroup difference. However, no significant difference was observed between the groups in the incidence of postoperative complications ($P > 0.05$). Detailed data were presented in Table 4.

Table 4 Comparison of postoperative complications and reoperation rates between the two groups

Group	Outcome indicators	Normal BMD group [n (%)]	Reduced BMD group [n (%)]	P-value
Before PSM	Postoperative complications	14(0.82)	2(0.85)	0.954
	Reoperation	25(1.46)	7(2.99)	0.084
After PSM	Postoperative complications	3(1.29)	2(0.86)	0.653
	Reoperation	1(0.43)	7(3.00)	0.032

Comparison of baseline characteristics between patients with and without postoperative complications

All patients were divided into two groups based on the presence or absence of postoperative complications: the complication group (n = 16) and the non-complication group (n = 1,929). Intergroup comparison revealed that the median BMD value in the complication group was significantly lower than that in the non-complication group (93.3 vs. 103.2, $P = 0.026$), indicating that decreased BMD is closely associated with the occurrence of postoperative complications. The relevant data were presented in Table 5.

Table 5 Comparison of baseline characteristics between patients with and without postoperative complications

Influencing factors			Non-complication group (n = 1,929)	Complication group (n = 16)	P-value
Gender [n (%)]					0.411
Man			672(34.84)	4(25.00)	
Woman			1257(65.16)	12(75.00)	
Age (years, $\bar{x} \pm s$)			63.3 $\pm$ 7.71	61.25 $\pm$ 7.94	0.289
BMI (kg/m ² , $\bar{x} \pm s$)			26.71 $\pm$ 3.72	26.19 $\pm$ 3.43	0.578
Mean	BMD	value	103.2(101.2,103.2)	93.3(87.0,103.2)	0.026
[$M(P_{25},P_{75})$]					

Regression analysis of risk factors for postoperative complications

Univariate logistic regression analysis identified age and mean BMD value ($P < 0.1$) as potential factors influencing postoperative complications following UKA. These variables, along with their interaction term, were included in the multivariate logistic regression model. The results indicated that the mean BMD value was an independent negative predictor of postoperative complications after UKA ($OR = 0.700$, 95% CI: 0.700–0.960, $P = 0.007$). Age was also an independent protective factor ($P = 0.008$), and there was a significant interaction effect between age and BMD ($P = 0.015$). These findings confirm that lower BMD is associated with a higher risk of postoperative complications after UKA. Detailed results were presented in Table 6.

Table 6 Regression analysis of risk factors for postoperative complications

Variable	Regression coefficient	Standard error	Z value	P value	95%CI
----------	------------------------	----------------	---------	---------	-------

Variable	Regression coefficient	Standard error	Z value	P value	95%CI
Intercept	19.109	8.164	2.341	0.019	5.048~4.16×10 ¹⁴
Age	-0.350	0.133	-2.643	0.008	0.555~0.931
Mean BMD value	-0.217	0.081	-2.686	0.007	0.700~0.960
Age : Mean BMD value	0.003	0.001	2.437	0.015	1.000~1.005

Predictive efficacy analysis of BMD value

ROC curve analysis was performed (Fig. 1). The AUC of mean BMD for predicting postoperative complications after UKA was 0.347 both before and after PSM, indicating that the predictive performance of BMD alone was limited. Nevertheless, combined with the results of regression analysis, BMD could serve as an independent early warning marker for postoperative complications, and its predictive accuracy could be further enhanced when combined with age and other covariates.

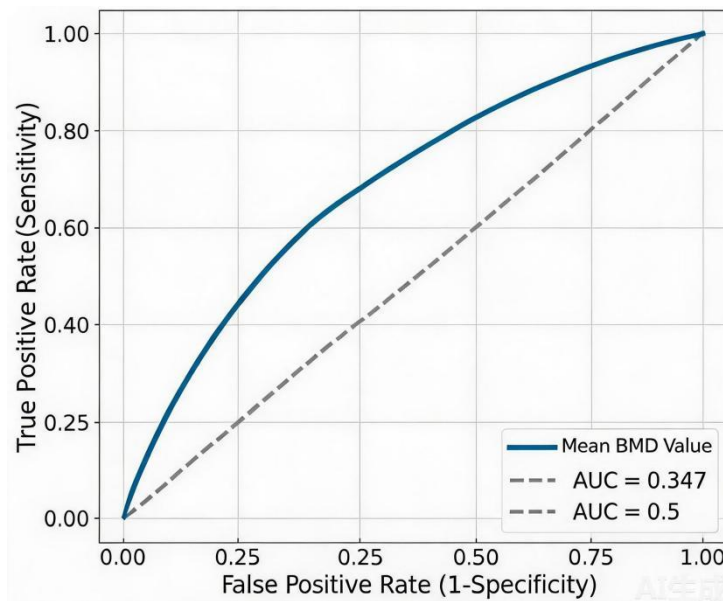


Fig. 1 ROC curve of BMD values for postoperative complications after UKA.

Discussion

UKA is a classic knee-preserving procedure whose primary advantages include the preservation of the native anatomical structure of the knee joint, reduced surgical trauma, and accelerated postoperative functional recovery. However, adverse complications such as

prosthetic loosening and subsequent revision surgery following UKA can significantly compromise surgical outcomes [1,2]. Bone quality is a key determinant of prognosis after orthopedic surgeries. Reduced BMD leads to decreased bone mass, sparse trabeculae, and impaired biomechanical stability, all of which hinder postoperative recovery after joint arthroplasty through multiple mechanisms [8]. Based on a large-sample retrospective cohort study combined with PSM to precisely balance confounding factors, the present study systematically confirmed that preoperative low BMD is an independent risk factor for reoperation and postoperative complications after UKA, highlighting the critical clinical value of BMD measurement for perioperative risk stratification in patients undergoing UKA.

Our results demonstrated that patients in the low BMD group exhibited a significantly higher reoperation rate. This phenomenon can be explained by the cascade of events involving bone mass, bone microarchitecture, biomechanics, and complications. Patients with low bone mass and reduced BMD have sparse trabeculae, which decrease the contact area at the bone-prosthesis interface and weaken the initial implant fixation strength. Increased micromotion of the prosthesis postoperatively subsequently induces fibrous membrane proliferation, substantially elevating the long-term risk of aseptic loosening [20]. Additionally, osteoporosis diminishes the bone's ability to withstand mechanical stress; osteotomy and bone levering during surgery often cause osseous injury, and minor daily activities or trivial falls postoperatively may trigger periprosthetic fractures, ultimately necessitating reoperation [21]. Furthermore, after implantation, the prosthesis bears most of the joint load, resulting in stress shielding of the proximal tibia. Combined with reduced physical activity due to postoperative pain, disuse bone loss is further exacerbated, creating a vicious cycle of reduced bone mass, complications, and progressive bone loss that severely compromises the long-term functional recovery of the knee joint [22].

The present study also revealed that patients with reduced BMD were more likely to suffer from chronic underlying conditions, including hypertension, diabetes mellitus, and coronary heart disease, accompanied by lower preoperative Hb levels. These findings are consistent with those of previous investigations [23-26]. Osteoporosis frequently coexists with sarcopenia, chronic metabolic disorders, and anemia. The coexistence of multiple pathological conditions further impairs postoperative tissue repair capacity, increases the risk of complications such as infection and venous thromboembolism, and prolongs the rehabilitation period [27,28]. Multivariate regression analysis confirmed that mean BMD served as an independent negative predictor of postoperative complications after unicompartmental knee arthroplasty (UKA); higher BMD was associated with a lower risk of adverse postoperative outcomes. This conclusion aligns with studies on total knee arthroplasty and hip fracture surgery, demonstrating the universal predictive value of BMD for postoperative prognosis following arthroplasty [9,29,30].

Current domestic and international studies on postoperative risk prediction after UKA predominantly focus on conventional factors such as surgical techniques, implant types, and patient age. However, quantitative research specifically targeting BMD remains scarce [13,31]. Innovatively, this study employed QCT to accurately quantify lumbar BMD and eliminated confounding baseline variables through PSM. We clarified the independent correlations between BMD and postoperative reoperation, as well as complications following UKA, offering novel research perspectives for assessing bone health risks in the context of UKA. Compared with traditional single clinical indicators, BMD measurement directly reflects patients' fundamental skeletal status and systemic metabolic levels, serving as a simple and efficient preoperative risk screening marker [32].

Several limitations of this study should be acknowledged. First, this was a single-center retrospective study, which imposed geographic restrictions on patient populations and treatment protocols, thereby limiting the generalizability of our findings. Second, we did not perform in-depth analyses of the effects of various anti-osteoporotic medications, postoperative rehabilitation regimens, and implant types on clinical outcomes. Additionally, subgroup analyses stratified by subtypes of underlying comorbidities were not conducted. Third, isolated lumbar BMD measurements cannot fully represent the local bone conditions of the knee joint. Future research should combine BMD assessments of the proximal femur and local knee bone to further optimize the evaluation system. Multi-center prospective cohort studies are warranted to develop more accurate combined prediction models for postoperative complications after UKA by integrating multi-site BMD measurements and bone turnover markers. Furthermore, the clinical efficacy of perioperative anti-osteoporotic interventions in improving surgical prognosis requires further investigation.

In conclusion, reduced preoperative BMD is an independent risk factor for postoperative complications and reoperation after UKA. Preoperative QCT-based BMD measurement can effectively identify high-risk patients. We recommend incorporating BMD screening into routine preoperative evaluation protocols for UKA. Individualized interventions should be implemented proactively for patients with low bone mass or osteoporosis to optimize perioperative bone health management and enhance postoperative monitoring for complications. These strategies can reduce the risk of reoperation and improve the long-term surgical outcomes for patients.

Acknowledgements

None.

Funding

The authors did not receive support from any organization for the submitted work. No funding was received to assist with the preparation of this manuscript.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Affiliated Hospital of Jining Medical University (Ethics Approval No. 2023C116), and the study was performed in accordance with the Declaration of Helsinki.

Consent for publication

Written informed consent was obtained from all patients.

Competing interests

The authors declare no competing interests.

Reference

- [1] Li P, Qiao Y, Zhou Y, Li J, Lin Z, Cao Y, et al. Comparative outcomes of revision total knee arthroplasty: a systematic review and meta-Analysis of high tibial osteotomy vs. unicompartmental knee arthroplasty. *BMC Musculoskelet Disord.* 2025;26(1):780. <https://doi.org/10.1186/s12891-025-08891-7>.
- [2] Levy KH, Fusco PJ, Salazar-Restrepo SA, Mathew DM, Pandey R, Ahmed S, et al. Unicompartmental knee arthroplasty revised to total knee arthroplasty versus primary total knee arthroplasty: A meta-analysis of matched studies. *Knee.* 2023;45:1-10. <https://doi.org/10.1016/j.knee.2023.09.001>.
- [3] Scheele CB, Pietschmann MF, Wagner TC, Müller PE. Functional outcomes and return to sports, work, and daily activities after revision UKA compared to primary UKA and TKA. *Orthopadie.* 2024;53(3):201-8. <https://doi.org/10.1007/s00132-024-04472-z>.
- [4] Mori Y, Tarasawa K, Tanaka H, Kamimura M, Harada K, Mori N, et al. Thromboembolic and infectious complication risks in TKA and UKA: evidence from a Japanese nationwide cohort. *Knee Surg Relat Res.* 2025;37(1):19. <https://doi.org/10.1186/s43019-025-00273-6>.
- [5] Walsh JM, Burnett RA, Serino J, Gerlinger TL. Painful Unicompartmental Knee Arthroplasty: Etiology, Diagnosis and Management. *Arch Bone Jt Surg.* 2024;12(8):546-57. <https://doi.org/10.22038/ABJS.2024.61787.3030>.

- [6] Nazlıgül AS, Güven Ş, Erdoğan Y, Fırat A, Doğan M, Akkaya M. Periprosthetic Joint Infection in Unicompartmental vs. Total Knee Arthroplasty: Microbiological Spectrum and Management Outcomes. *Antibiotics*. 2025;14(6):585. <https://doi.org/10.3390/antibiotics14060585>.
- [7] Gadeyne S, Menon A, Lustig S. Long-term outcomes of a 3D printed cementless fixed bearing unicompartmental knee arthroplasty. *Arch Orthop Trauma Surg*. 2025;145(1):339. <https://doi.org/10.1007/s00402-025-05952-3>.
- [8] Liu D, Wang X, Dong X, Liu M, Ji G, Liu G. Attention Should Be Paid to the Bone Mineral Density Status of Patients Undergoing Unicompartmental Knee Arthroplasty: A 1,164-Case Follow-Up Study. *J Arthroplasty*. 2026:S0883-5403(26)00264-0. <https://doi.org/10.1016/j.arth.2026.03.061>.
- [9] Meyer M, Leiß F, Götz JS, Holzapfel DE, Grifka J, Weber M. Bone Mineral Density is Associated With Adverse Events but not Patient-Reported Outcomes in Total Hip and Knee Arthroplasty. *J Arthroplasty*. 2024;39(2):320-5. <https://doi.org/10.1016/j.arth.2023.08.056>.
- [10] Kubo M, Nosaka Y, Hasegawa T, Kumagai K, Amano Y, Isoya E, et al. Osteoporosis should be evaluated by bone mineral density at the combination of the lumbar spine and ipsilateral femoral neck in female patients with knee osteoarthritis scheduled for knee arthroplasty: A retrospective observational study. *J Orthop Sci*. 2025;30(3):513-7. <https://doi.org/10.1016/j.jos.2024.07.005>.
- [11] Feng Y, Lin J, Zheng C, Wang J, Yang Q, Wang J. Osteoporosis exacerbates perioperative complications in total knee arthroplasty: a 10-Year nationwide analysis. *J Orthop Surg Res*. 2025;20(1):995. <https://doi.org/10.1186/s13018-025-06340-8>.
- [12] Madsen RV, Nam D, Schilcher J, Dvorzhinskiy A, Sutherland JP, Bostrom FM, et al. Mechanical instability induces osteoclast differentiation independent of the presence of a fibrous tissue interface and osteocyte apoptosis in a rat model for aseptic loosening. *Acta Orthop*. 2020;91(1):115-20. <https://doi.org/10.1080/17453674.2019.1695351>.
- [13] Park YB, Kim M, Nam HC, Jeon JW, Ha CW. Total knee arthroplasty and periprosthetic distal femoral fracture: looking beyond the osteoporosis to previous osteoporotic fracture. *Osteoporos Int*. 2024;35(8):1469-75. <https://doi.org/10.1007/s00198-024-07138-w>.
- [14] ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care*. 2023;46(Suppl 1):S19-S40. <https://doi.org/10.2337/dc23-S002>.
- [15] Idasiak-Piechocka I, Lewandowski D, Świąg W, Kalinowski J, Mikosza K, Suchowiejski P, et al. Effect of hypoalbuminemia on drug pharmacokinetics. *Front Pharmacol*. 2025;16:1546465. <https://doi.org/10.3389/fphar.2025.1546465>.

- [16] Jeemon P, Séverin T, Amodeo C, Balabanova D, Campbell NRC, Gaita D, et al. World Heart Federation Roadmap for Hypertension - A 2021 Update. *Glob Heart*. 2021;16(1):63. <https://doi.org/10.5334/gh.1066>.
- [17] Xue HY, Shen XL, Wang ZH, Bi HC, Xu HG, Wu J, et al. Research progress on mesenchymal stem cell-derived exosomes in the treatment of osteoporosis induced by knee osteoarthritis (Review). *Int J Mol Med*. 2025;56(4):160. <https://doi.org/10.3892/ijmm.2025.5601>.
- [18] Parvizi J, Tan TL, Goswami K, Higuera C, Della Valle C, Chen AF, et al. The 2018 Definition of Periprosthetic Hip and Knee Infection: An Evidence-Based and Validated Criteria. *J Arthroplasty*. 2018;33(5):1309-14.e2. <https://doi.org/10.1016/j.arth.2018.02.078>.
- [19] Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. *Clin Infect Dis*. 2013;56(1):e1-e25. <https://doi.org/10.1093/cid/cis803>.
- [20] Zhu Y, Zeng Q, Shi Y, Qin Y, Liu S, Yang Y, et al. Association between sarcopenia and osteoporosis: the cross-sectional study from NHANES 1999-2020 and a bi-directions Mendelian randomization study. *Front Endocrinol*. 2024;15:1399936. <https://doi.org/10.3389/fendo.2024.1399936>.
- [21] Rashid A, Chaudhary Hauge S, Suetta C, Hansen D. Sarcopenia and risk of osteoporosis, falls and bone fractures in patients with chronic kidney disease: A systematic review. *PLoS One*. 2022;17(1):e0262572. <https://doi.org/10.1371/journal.pone.0262572>.
- [22] Li Y, Gao H, Zhao L, Wang J. Osteoporosis in COPD patients: Risk factors and pulmonary rehabilitation. *Clin Respir J*. 2022;16(7):487-96. <https://doi.org/10.1111/crj.13514>.
- [23] Delitala AP, Scuteri A, Doria C. Thyroid Hormone Diseases and Osteoporosis. *J Clin Med*. 2020;9(4):1034. <https://doi.org/10.3390/jcm9041034>.
- [24] Kristjansdottir HL, Mellström D, Johansson P, Karlsson M, Vandenput L, Lorentzon M, et al. Anemia is associated with increased risk of non-vertebral osteoporotic fractures in elderly men: the MrOS Sweden cohort. *Arch Osteoporos*. 2022;17(1):85. <https://doi.org/10.1007/s11657-022-01130-9>.
- [25] Ishii Y, Noguchi H, Sato J, Takahashi I, Ishii H, Ishii R, et al. Preoperative bone assessment by bone mineral density and bone turnover in patients undergoing total knee arthroplasty. *J Orthop*. 2021;28:121-5. <https://doi.org/10.1016/j.jor.2021.11.011>.
- [26] Giurazza G, Edoardo Cardinale M, Franceschetti E, Campi S, Papalia GF, Gregori P, et al. Bisphosphonate use in patients undergoing total knee arthroplasty reduces overall and aseptic revisions and periprosthetic bone mineral density loss: A systematic review from the FP-UCBM Knee Study Group. *Knee Surg Sports Traumatol Arthrosc*. 2026;34(1):203-13. <https://doi.org/10.1002/ksa.12802>.

- [27] Delsmann MM, Schmidt C, Mühlenfeld M, Jandl NM, Boese CK, Beil FT, et al. Prevalence of osteoporosis and osteopenia in elderly patients scheduled for total knee arthroplasty. *Arch Orthop Trauma Surg.* 2022;142(12):3957-64. <https://doi.org/10.1007/s00402-021-04297-x>.
- [28] Guo H, Xu K, Deng F, Chen Q, Liang J, Zhang K. Risk Prediction Models for Preoperative Deep Vein Thrombosis in Older Patients with Hip Fracture: A Systematic Review and Meta-Analysis. *Clin Appl Thromb Hemost.* 2024;30:10760296241285565. <https://doi.org/10.1177/10760296241285565>.
- [29] Guo YF, Zhang D, Guo A, Tong B, Champ M, Gao N, et al. Optimizing Preoperative Venous Thromboembolism Risk Assessment in Elderly Hip Fracture Patients: A Refined Caprini Model Integrating D-Dimer and Injury-to-Admission Time. *Clin Appl Thromb Hemost.* 2025;31:10760296251396133. <https://doi.org/10.1177/10760296251396133>.
- [30] Ge Y, Chen Y, Liu G, Zhu S, Li B, Tian M, et al. Association Between Hip Bone Mineral Density and Mortality Risk After Hip Fracture: A Prospective Cohort Study. *Calcif Tissue Int.* 2023;113(3):295-303. <https://doi.org/10.1007/s00223-023-01109-9>.
- [31] Castagna A, Pujia C, Mazza E, Maurotti S, Ferro Y, Rizzo V, et al. Underlying Mechanisms of Osteoporosis in the Context of Multimorbidity: Clinical Challenges and Management Strategies. *Nutrients.* 2026;18(2):262. <https://doi.org/10.3390/nu18020262>.
- [32] Kuang C, Shang J, Ma M, Huang S, Yan B, Zhong Y, et al. Risk factors and clinical prediction models for osteoporosis in pre-dialysis chronic kidney disease patients. *Ren Fail.* 2024;46(2):2361802. <https://doi.org/10.1080/0886022X.2024.2361802>.