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Preoperative Bone Marrow Lesion Severity and Early Quality of Recovery After Medial Unicompartmental Knee Arthroplasty: A Retrospective Cohort Study

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Research Article

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Abstract

Background

The prognostic significance of preoperative bone marrow lesions (BMLs) after medial unicompartmental knee arthroplasty (UKA) remains uncertain. This study investigated the association between preoperative medial BML severity and early postoperative quality of recovery.

Methods

This single-centre retrospective cohort study included 173 patients who underwent medial UKA between December 2024 and August 2025. Preoperative magnetic resonance imaging was used to calculate a composite medial BML score ranging from 0 to 6. Patients were classified into no-BML (n = 36), mild (n = 60), moderate (n = 42), and severe (n = 35) groups. The primary outcome was the Quality of Recovery-15 (QoR-15) score at discharge. Secondary outcomes included postoperative pain area under the curve (AUC), knee circumference change, and Knee Society Scores (KSS) at 3, 6, and 12 months. Associations were assessed using Spearman correlation and multivariable linear regression with HC3 robust standard errors. False discovery rate (FDR) adjustment across 20 outcomes was performed as a sensitivity analysis.

Results

Mean discharge QoR-15 scores were 134.92 ± 6.87, 132.98 ± 6.70, 130.62 ± 8.76, and 130.17 ± 9.14 across increasing BML severity groups (P = 0.031). After covariate adjustment, each one-point increase in BML score was associated with a 0.755-point decrease in QoR-15 (95% CI − 1.384 to − 0.125; P = 0.019) and a 0.125-cm increase in postoperative knee circumference change (95% CI 0.010–0.241; P = 0.034). Neither association remained statistically significant after FDR adjustment (q = 0.125 and q = 0.169, respectively). No clear associations were observed with postoperative pain AUC or KSS during the first postoperative year.

Conclusions

Greater preoperative medial BML severity showed nominal associations with poorer early recovery quality and greater postoperative knee swelling, although these findings did not remain statistically significant after multiplicity adjustment. By examining discharge QoR-15 rather than solely knee-specific outcomes, this study addresses a less-explored dimension of recovery after medial UKA. Further prospective validation is required before medial BML severity can be used as an independent prognostic indicator.

Introduction

Medial unicompartmental knee arthroplasty (UKA) is an established treatment for osteoarthritis predominantly affecting the medial compartment. Compared with total knee arthroplasty, UKA preserves more native joint structures and may allow earlier postoperative recovery in appropriately selected patients[1]. Nevertheless, recovery varies among patients, highlighting the need to identify preoperative factors associated with postoperative outcomes.

Bone marrow lesions (BMLs) are common MRI findings in knee osteoarthritis and encompass various subchondral abnormalities rather than simple marrow oedema [2]. Previous studies have linked BMLs to knee pain and structural progression [3, 4]. Their prognostic relevance after UKA, however, remains uncertain. Yang et al. reported that preoperative bone marrow oedema was associated with worse WOMAC pain and Forgotten Joint Scores at a mean follow-up of 10 years [5]. Conversely, Jacobs et al. and Berend et al. found no consistent association between preoperative BMLs and inferior postoperative pain or function [6, 7]. A subsequent systematic review and meta-analysis likewise reported no significant overall association between BMLs and clinical outcomes after UKA [8].

Previous studies of BMLs in UKA have mainly examined pain, knee-specific function, and medium- to long-term outcomes. These measures may not fully reflect the broader experience of early postoperative recovery. The 15-item Quality of Recovery questionnaire (QoR-15) captures physical comfort, independence, psychological support, emotional state, and pain [9], with established validity, reliability, and responsiveness across surgical populations [10]. However, evidence linking preoperative BML severity to early QoR-15 outcomes after UKA remains limited. We therefore examined the association between preoperative medial BML severity and QoR-15 at discharge, alongside early pain burden, knee swelling, and knee function during the first postoperative year.

Materials and Methods

Study design and ethical approval

This single-centre retrospective cohort study was based on electronic medical records, laboratory data, and routine postoperative follow-up records. The study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University (approval No. JD-HG-2025-134), which waived the requirement for individual informed consent. All data were de-identified before analysis.

Study population

We screened adults undergoing primary unilateral medial UKA between December 2024 and August 2025 who had undergone ipsilateral knee MRI within 3 months before surgery. Eligibility required clinically and radiographically diagnosed predominantly medial-compartment osteoarthritis. Exclusions comprised traumatic or inflammatory arthritis, osteonecrosis or osteochondritis dissecans, prior surgery

on the index knee, symptomatic disease of the lateral or patellofemoral compartment incompatible with UKA, BMLs in the lateral or patellar compartments, unavailable essential records, or loss to follow-up. Of 211 screened patients, 15 lacked a preoperative MRI, 9 had lateral or patellar BMLs, 8 had previous index-knee surgery, and 6 were lost to follow-up; 173 remained for analysis. Their 12-month follow-up was complete by August 2026 (Fig. 1).

MRI assessment and BML severity classification

Preoperative knee MRI was performed using a 1.5-T scanner within 3 months before surgery. BML severity was assessed using a simplified two-region semiquantitative scoring method adapted from the MRI Osteoarthritis Knee Score (MOAKS) framework and the approach described by Yang et al [2, 5]. The medial femoral condyle and medial tibial plateau were scored separately according to the maximum extent of BML involvement: grade 0, no lesion; grade 1, less than one-third of the assessed region; grade 2, one-third to two-thirds; and grade 3, more than two-thirds. When multiple lesions were present within a region, the largest lesion determined the regional score. The two scores were summed to obtain a composite medial BML score ranging from 0 to 6. Patients were categorised as having no (0), mild (1–2), moderate (3–4), or severe (5–6) BMLs. This simplified composite did not represent the complete MOAKS score (Fig. 2).

Two physicians independently assessed the preoperative MRI examinations using the same predefined scoring criteria. Both observers were blinded to postoperative clinical outcomes, including QoR-15, VAS, and KSS, and neither had access to the other observer's ratings during the initial assessment. Disagreements were resolved through discussion, and the resulting consensus scores were used for patient classification and subsequent statistical analyses.

Surgical procedures and perioperative management

All patients underwent medial UKA under general anaesthesia through a medial parapatellar approach. The available protocol documented tourniquet use, intravenous tranexamic acid, antibiotic prophylaxis, and routine enhanced recovery care. Periarticular infiltration was recorded as 20 mL of 0.2% ropivacaine with 0.4 mg adrenaline, diluted with saline to 100 mL. Postoperatively, an elastic bandage and multimodal analgesia were used. The protocol described flurbiprofen axetil 50 mg intravenously twice daily for the first two postoperative days, additional opioid analgesia when pain remained greater than 6/10, and subsequent oral celecoxib continued for 4 weeks after discharge.

Outcomes and data collection

Two investigators extracted demographic characteristics, diabetes status, baseline knee measures, operative variables, postoperative symptoms, laboratory findings, and follow-up scores. The prespecified

primary outcome was the QoR-15 total score at hospital discharge (range 0–150; higher scores indicate better recovery).

Secondary outcomes included the area under the curve (AUC)[11] for resting and passive-motion visual analogue scale (VAS) pain scores from 24 to 72 hours postoperatively, changes in knee circumference at discharge, and Knee Society Scores (KSS) at 3, 6, and 12 months, assessed using the 2011 Knee Society Scoring System [12]. The AUC was calculated by the trapezoidal rule from the 24-, 48-, and 72-hour observations (VAS-hours). Knee circumference was measured 5 cm above the superior patellar border in extension, and change was defined as discharge minus preoperative circumference. Single-time-point VAS measurements, discharge range of motion, postoperative length of stay, recorded analgesic amount, C-reactive protein, neutrophil percentage, and white blood cell count were exploratory outcomes.

Statistical analysis

Distributional assumptions were assessed using Shapiro–Wilk testing. Continuous variables are reported as mean ± standard deviation or median (interquartile range), as appropriate; categorical variables are shown as n (%). Four-group comparisons used one-way analysis of variance, Welch analysis of variance, or Kruskal–Wallis testing as appropriate and chi-square or Fisher exact tests for categorical variables. Spearman coefficients were calculated between the continuous BML score and each outcome.

The primary association was assessed using multivariable linear regression, with discharge QoR-15 as the dependent variable and continuous BML score as the exposure. All models were adjusted for age, sex, body mass index, diabetes mellitus, preoperative KSS, and preoperative range of motion. Preoperative resting VAS was additionally included in the primary QoR-15 model and resting pain models, whereas preoperative passive-motion VAS was included in passive-motion pain models. Preoperative knee circumference was additionally included in the model for postoperative knee circumference change. HC3 heteroskedasticity-consistent standard errors were used to obtain robust confidence intervals [13]. The Benjamini-Hochberg procedure was applied across the 20 reported outcome regressions as a sensitivity analysis for multiple testing [14]. Unstandardised regression coefficients, 95% confidence intervals, nominal P values, and FDR-adjusted q values were reported. Each model was based on complete cases. Statistical analyses were performed in Python using the SciPy and statsmodels packages.

Use of AI-assisted tools

ChatGPT (OpenAI) was used to assist with English language editing, manuscript organization, and review of statistical code. All statistical analyses, numerical results, and AI-assisted content were independently checked and verified by the authors, who take full responsibility for the accuracy and integrity of the manuscript.

Results

Patient characteristics

Among the 173 included patients, 36 had no medial BML, 60 had mild lesions, 42 had moderate lesions, and 35 had severe lesions. Baseline range of motion differed across groups (P = 0.004), whereas age, sex, body mass index, diabetes prevalence, and baseline KSS showed no statistically significant between-group differences. Postoperative length of stay also showed a nominal group difference (P = 0.041; Table 1).

Table 1
Demographic, baseline clinical, and operative characteristics

Characteristic	No BML (36)	Mild (60)	Moderate (42)	Severe (35)	P
Sex					
Men	6 (16.67%)	16 (26.67%)	8 (19.05%)	8 (22.86%)	0.662
Women	30 (83.33%)	44 (73.33%)	34 (80.95%)	27 (77.14%)	
Age (yr)	67.44 ± 6.67	68.07 ± 6.38	67.50 ± 7.53	67.86 ± 6.72	0.966
BMI (kg/m²)	25.60 (23.58, 28.03)	26.37 (24.22, 28.67)	25.33 (23.19, 27.91)	24.56 (23.27, 27.25)	0.162
Diabetes mellitus, n (%)	9 (25.00%)	17 (28.33%)	11 (26.19%)	10 (28.57%)	0.980
Preoperative KSS (points)	36.00 (30.25, 38.75)	32.00 (30.00, 37.00)	34.00 (27.25, 38.00)	33.00 (27.00, 37.50)	0.495
Preoperative ROM (°)	129.00 (119.50, 135.00)	120.00 (114.50, 125.75)	125.00 (116.25, 130.00)	116.00 (110.00, 125.00)	**0.004**
Preoperative resting VAS	2.00 (1.00, 3.00)	2.00 (1.75, 3.00)	2.00 (2.00, 3.00)	2.00 (1.00, 3.00)	0.747
Preoperative passive-motion VAS	5.00 (4.00, 5.00)	5.00 (4.00, 6.00)	5.00 (5.00, 6.00)	5.00 (4.00, 5.00)	0.071
Preoperative knee circumference (cm)	37.60 (34.75, 39.00)	37.65 (36.00, 39.62)	37.10 (34.02, 39.75)	36.70 (34.00, 38.00)	0.296
Operative time (min)	85.00 (70.00, 95.00)	90.00 (75.00, 91.25)	85.00 (70.00, 100.00)	89.00 (80.00, 100.00)	0.706
Perioperative blood loss (mL)	50.00 (50.00, 90.00)	50.00 (50.00, 65.00)	50.00 (50.00, 100.00)	50.00 (50.00, 100.00)	0.551
Postoperative length of stay (days)	4.00 (3.00, 4.00)	4.00 (3.00, 4.00)	4.00 (4.00, 4.00)	4.00 (4.00, 5.00)	**0.041**

Values are mean ± SD, median (IQR), or n (%), as appropriate. P values refer to unadjusted four-group comparisons.

BML severity and early quality of recovery

Mean QoR-15 scores at discharge were 134.92 ± 6.87, 132.98 ± 6.70, 130.62 ± 8.76, and 130.17 ± 9.14 in the no-BML, mild, moderate, and severe groups, respectively (four-group P = 0.031; Table 2 and Fig. 3). Continuous BML score correlated weakly with QoR-15 (Spearman ρ=−0.199; P = 0.009). In the adjusted HC3 model, each one-point increase in BML score corresponded to a 0.755-point lower QoR-15 (95% CI − 1.384 to − 0.125; P = 0.019). The 20-outcome FDR-adjusted q value was 0.125 (Table 5).

Table 2
Early postoperative recovery and pain measures

Characteristic	No BML (36)	Mild (60)	Moderate (42)	Severe (35)	P
QoR-15 at discharge (points)	134.92 ± 6.87	132.98 ± 6.70	130.62 ± 8.76	130.17 ± 9.14	**0.031**
Knee circumference change (cm)	1.94 ± 0.89	1.99 ± 1.28	2.26 ± 1.10	2.67 ± 1.44	**0.033**
ROM at discharge (°)	105.25 ± 11.00	106.62 ± 8.97	104.10 ± 9.98	106.97 ± 8.30	0.491
Resting VAS at 24 h	1.44 ± 0.73	1.33 ± 0.71	1.33 ± 0.75	1.34 ± 0.73	0.887
Resting VAS at 48 h	1.00 ± 0.59	1.13 ± 0.62	1.02 ± 0.52	0.89 ± 0.53	0.237
Resting VAS at 72 h	0.67 ± 0.53	0.87 ± 0.43	0.71 ± 0.46	0.60 ± 0.50	**0.043**
Passive-motion VAS at 24 h	3.47 ± 1.03	3.52 ± 0.85	3.57 ± 1.13	3.66 ± 1.06	0.873
Passive-motion VAS at 48 h	2.86 ± 0.99	2.75 ± 0.73	3.00 ± 0.88	2.77 ± 0.81	0.485
Passive-motion VAS at 72 h	1.75 ± 0.69	1.75 ± 0.68	1.76 ± 0.69	1.60 ± 0.65	0.697
Resting VAS AUC (VAS·h)	49.33 ± 25.46	53.60 ± 24.85	49.14 ± 22.46	44.57 ± 21.89	0.357
Passive-motion VAS AUC (VAS·h)	131.33 ± 38.69	129.20 ± 30.32	136.00 ± 36.50	129.60 ± 33.16	0.777

Values are mean ± SD; unadjusted four-group P values are shown. Pain AUC covers postoperative hours 24–72 (VAS-hours).

BML severity and postoperative knee swelling

The discharge circumference increases were 1.94 ± 0.89, 1.99 ± 1.28, 2.26 ± 1.10, and 2.67 ± 1.44 cm across ascending BML categories (P = 0.033). BML score had a weak positive Spearman correlation with circumference change (ρ = 0.208; P = 0.006). The adjusted coefficient was 0.125 cm per score point (95% CI 0.010–0.241; P = 0.034), whereas the FDR q value was 0.169 (Table 5).

BML severity and postoperative pain burden

Resting and passive-motion VAS scores decreased over postoperative hours 24, 48, and 72 (Fig. 4). Group differences were not statistically significant for resting pain AUC (P = 0.357) or passive-motion pain AUC (P = 0.777). Adjusted coefficients were − 0.835 VAS-hours (95% CI − 2.584 to 0.915; P = 0.350) and 1.024 VAS-hours (95% CI − 1.773 to 3.822; P = 0.473), respectively. Resting VAS at 72 hours differed among groups in unadjusted comparison (P = 0.043), but not in the adjusted model (P = 0.206).

Knee outcomes during the first postoperative year

Mean KSS across the cohort was 72.38, 77.60, and 80.41 at 3, 6, and 12 months. Group means increased descriptively across follow-up visits (Fig. 5), but no between-group difference was detected at any individual visit (Table 3). Adjusted BML coefficients were − 0.092 (P = 0.532), − 0.079 (P = 0.668), and − 0.004 (P = 0.986), respectively. No longitudinal group-by-time interaction was tested; trajectories are descriptive only.

Table 3
Knee Society Scores during follow-up

Outcome	No BML (36)	Mild (60)	Moderate (42)	Severe (35)	P
KSS at 3 months	72.83 ± 3.51	72.45 ± 3.94	72.05 ± 4.31	72.17 ± 3.22	0.813
KSS at 6 months	78.13 ± 4.63	77.53 ± 4.64	76.97 ± 5.69	77.94 ± 4.34	0.725
KSS at 12 months	80.89 ± 4.70	80.16 ± 4.81	79.94 ± 6.13	80.89 ± 5.03	0.782
KSS change, 3 to 6 months	5.30 ± 3.79	5.08 ± 3.14	4.93 ± 3.40	5.77 ± 3.71	0.728
KSS change, 6 to 12 months	2.75 ± 2.72	2.63 ± 2.92	2.97 ± 2.72	2.94 ± 2.73	0.925
KSS change, 3 to 12 months	8.05 ± 4.54	7.71 ± 3.70	7.90 ± 4.42	8.71 ± 4.64	0.734

Values are mean ± SD. Follow-up observations were compared separately; no group-by-time inference is implied.

Exploratory laboratory and other outcomes

- reactive protein was available in 157 patients and neutrophil percentage and white blood cell count in 172 each (Table 4). BML score showed nominal inverse associations with neutrophil percentage (adjusted β=−0.963, P = 0.014) and white blood cell count (β=−0.316, P = 0.011); neither remained statistically significant after FDR adjustment (both q = 0.125). There was no significant association with C-reactive protein (P = 0.375), discharge range of motion (P = 0.829), or length of stay in the adjusted model (P = 0.119).

Table 4
Exploratory laboratory parameters by BML severity

Parameter	No BML (36)	Mild (60)	Moderate (42)	Severe (35)	P
C-reactive protein (CRP;mg/L)	20.50 (9.28, 68.17)	48.70 (16.88, 82.80)	54.40 (24.05, 97.70)	45.90 (19.73, 71.83)	0.064
Neutrophil percentage (%)	79.85 (74.32, 86.35)	81.25 (73.65, 87.70)	77.50 (72.95, 84.07)	74.15 (68.65, 84.38)	0.085
White blood cell count(×10⁹/L)	8.75 (7.55, 10.75)	10.55 (8.47, 12.77)	8.85 (7.50, 11.22)	7.50 (5.93, 11.05)	**0.012**

Median (interquartile range). CRP n = 157; neutrophils and WBC n = 172 each.

Table 5
Adjusted associations with preoperative medial BML score

Outcome	n	Adjusted β	95% CI	P	FDR q
QoR-15 at discharge	173	-0.755	-1.384 to -0.125	0.019	0.125
Circumference change, cm	173	0.125	0.010 to 0.241	0.034	0.169
Resting VAS AUC	173	-0.835	-2.584 to 0.915	0.350	0.749
Passive-motion VAS AUC	173	1.024	-1.773 to 3.822	0.473	0.786
KSS, month 3	173	-0.092	-0.381 to 0.197	0.532	0.786
KSS, month 6	173	-0.079	-0.442 to 0.283	0.668	0.786
KSS, month 12	173	-0.004	-0.396 to 0.389	0.986	0.998

Unstandardised adjusted coefficients are expressed per 1-point increase in BML score. HC3 robust standard errors were used. The Benjamini-Hochberg FDR sensitivity analysis included all 20 outcome regression models, of which seven are presented in Table 5 and the remaining 13 secondary and exploratory outcomes are reported in Additional file 1. Nominal P values are unadjusted for multiplicity.

Discussion

The main finding was a small, nominally significant inverse association between preoperative medial BML severity and discharge QoR-15 score, together with a nominal positive association with

circumference increase. Neither association survived correction across 20 reported outcomes. No consistent association was found with acute pain AUC or KSS during the first year. These data indicate a possible early recovery signal rather than a validated prognostic biomarker.

Comparison with previous UKA studies

Previous studies have reported conflicting associations between preoperative BMLs and outcomes after UKA. Yang et al. linked greater BML severity to worse long-term WOMAC pain and Forgotten Joint Scores [5], whereas Jacobs et al. and Berend et al. found no consistent association with inferior postoperative outcomes [6, 7]. A subsequent systematic review and meta-analysis also found no significant overall association [8]. Our results are broadly consistent with these latter findings regarding knee-specific outcomes during the first postoperative year. However, the discrepancy with the long-term findings of Yang et al. should be interpreted in light of differences in follow-up duration and outcome measures. KSS, WOMAC, and Forgotten Joint Score assess related but distinct aspects of knee recovery, and the absence of an association with one-year KSS does not exclude a relationship with longer-term pain or joint awareness.

Early quality of recovery and swelling

The QoR-15 captures aspects of early recovery beyond knee-specific pain and function [9, 10]. In our cohort, the mean discharge score differed by 4.75 points between patients without BMLs and those with severe BMLs. Myles et al. reported an approximately 8-point minimal clinically important difference in a mixed surgical population [15]. However, this threshold may not be directly applicable to between-group differences after UKA, particularly without baseline QoR-15 scores or an anchor-based assessment. Moreover, the association did not remain statistically significant after FDR adjustment. These findings therefore require confirmation before BML severity can be considered clinically useful for predicting early recovery.

Knee circumference increased more in patients with greater preoperative BML severity, although the association was not significant after multiplicity adjustment. Histopathological studies have linked osteoarthritis-related BMLs to heterogeneous subchondral changes [16], including microdamage, altered bone resorption, and vascular abnormalities [17]. These findings support the view that BMLs reflect underlying mechanical and structural disturbances [18]. However, postoperative knee circumference is influenced by surgical trauma, effusion, and periarticular soft-tissue swelling. As none of these processes was directly assessed in the present study, the observed association should not be interpreted as evidence of a specific inflammatory mechanism.

Early pain and follow-up knee scores

No clear association was observed between preoperative BML severity and resting or passive-motion VAS AUC during the first 72 postoperative hours. Previous longitudinal studies have linked enlarging BMLs to knee pain and structural progression in osteoarthritis [19, 20]. Changes in BML extent have also been associated with cartilage loss, while meniscal abnormalities may contribute to lesion development

or enlargement [4, 21, 22]. However, these findings concern the natural history of osteoarthritis rather than acute postoperative pain. Pain following UKA is influenced by surgical tissue injury, rehabilitation activities, and analgesic treatment, which may obscure associations present before surgery. In addition, analgesic exposure could not be reliably standardised from the available records. These factors may partly explain the absence of a clear association with early postoperative pain AUC.

Mean KSS increased descriptively at 3, 6, and 12 months, but no association with preoperative medial BML severity was detected at any individual visit. Because no BML-by-time interaction was tested, these observations cannot establish equivalent recovery trajectories across groups. BML location may also influence clinical relevance[23]. Yang et al. examined patellar oedema in relation to patellofemoral-specific outcomes after UKA [24], Cao et al. evaluated the influence of concomitant lateral-compartment BMLs on midterm outcomes following medial UKA and found that mild lateral lesions were not independently associated with inferior postoperative patient-reported outcomes in appropriately selected patients [25]. Similarly, Suda et al. reported no significant association between tibial intercondylar BMLs and inferior postoperative knee function [26].These findings underscore the importance of anatomical location when evaluating BMLs. Our assessment was restricted to the medial femoral condyle and tibial plateau; therefore, the results should not be extrapolated to lesions involving other compartments.

Strengths and limitations

This study evaluated preoperative medial BML severity in relation to a multidimensional measure of early recovery and several knee-specific outcomes. The use of a defined MRI-based composite and independently reproduced regression analyses strengthened the consistency of outcome reporting. Nevertheless, the retrospective, single-centre design remains susceptible to selection bias and residual confounding. The simplified BML score did not capture detailed lesion distribution or volume, and potentially relevant factors, including lower-limb alignment and structural disease severity, were not included in the adjusted models. Although MRI assessments were performed independently by two physicians and disagreements were resolved by consensus, the individual pre-consensus ratings were not retained. Therefore, interobserver reliability could not be quantified, which limits the assessment of reproducibility of the BML grading method. QoR-15 was assessed only at discharge, potentially at different postoperative times. Incomplete laboratory records, unstandardised analgesic exposure, multiple comparisons, and the limited follow-up period further constrain interpretation.

Preoperative MRI findings should therefore be interpreted alongside established UKA selection criteria, including symptom distribution, compartment involvement, ligament integrity, and other relevant clinical factors [27]. Our findings do not support using medial BML severity alone to determine surgical eligibility or predict individual postoperative recovery.

Conclusions

Preoperative medial BML severity was nominally associated with lower QoR-15 scores and greater knee circumference increases at discharge after medial UKA. However, neither association remained statistically significant after adjustment for multiple testing. No clear association was observed with early postoperative pain burden or KSS during the first postoperative year. Further prospective studies are needed to establish whether medial BML severity provides clinically useful prognostic information.

Abbreviations

AUC
Area under the curve
BML
Bone marrow lesion
BMI
Body mass index
CI
Confidence interval
CRP
C-reactive protein
FDR
False discovery rate
KSS
Knee Society Score
MOAKS
MRI Osteoarthritis Knee Score
MRI
Magnetic resonance imaging
QoR-15
Quality of Recovery-15
ROM
Range of motion
UKA
Unicompartmental knee arthroplasty
VAS
Visual analogue scale

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University on 18 November 2025 (approval No. JD-HG-2025-134). The study was conducted in

accordance with the Declaration of Helsinki. The requirement for individual informed consent was waived by the Ethics Committee because the study involved retrospective analysis of existing medical records..

Consent for publication

Not applicable. This manuscript does not include identifiable individual data, images, or personal information.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Yan Xu, Peng Yuan, and Shendong Wang contributed equally to this work and share first authorship. Yan Xu and Chang She conceived and designed the study. Yan Xu and Peng Yuan performed the statistical analyses and interpreted the data. Shendong Wang contributed to clinical data collection and organization. Yiwei Song contributed to the preparation of figures and tables. Yan Xu and Weiqing Li drafted the manuscript. Wei Xu and Chang She jointly supervised the study, contributed to the interpretation of the results, and critically revised the manuscript for important intellectual content. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

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Data Availability

The datasets used in this study are not publicly available because of privacy and ethics restrictions. De-identified data may be available from the corresponding author on reasonable request and after institutional review board approval.

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Figures

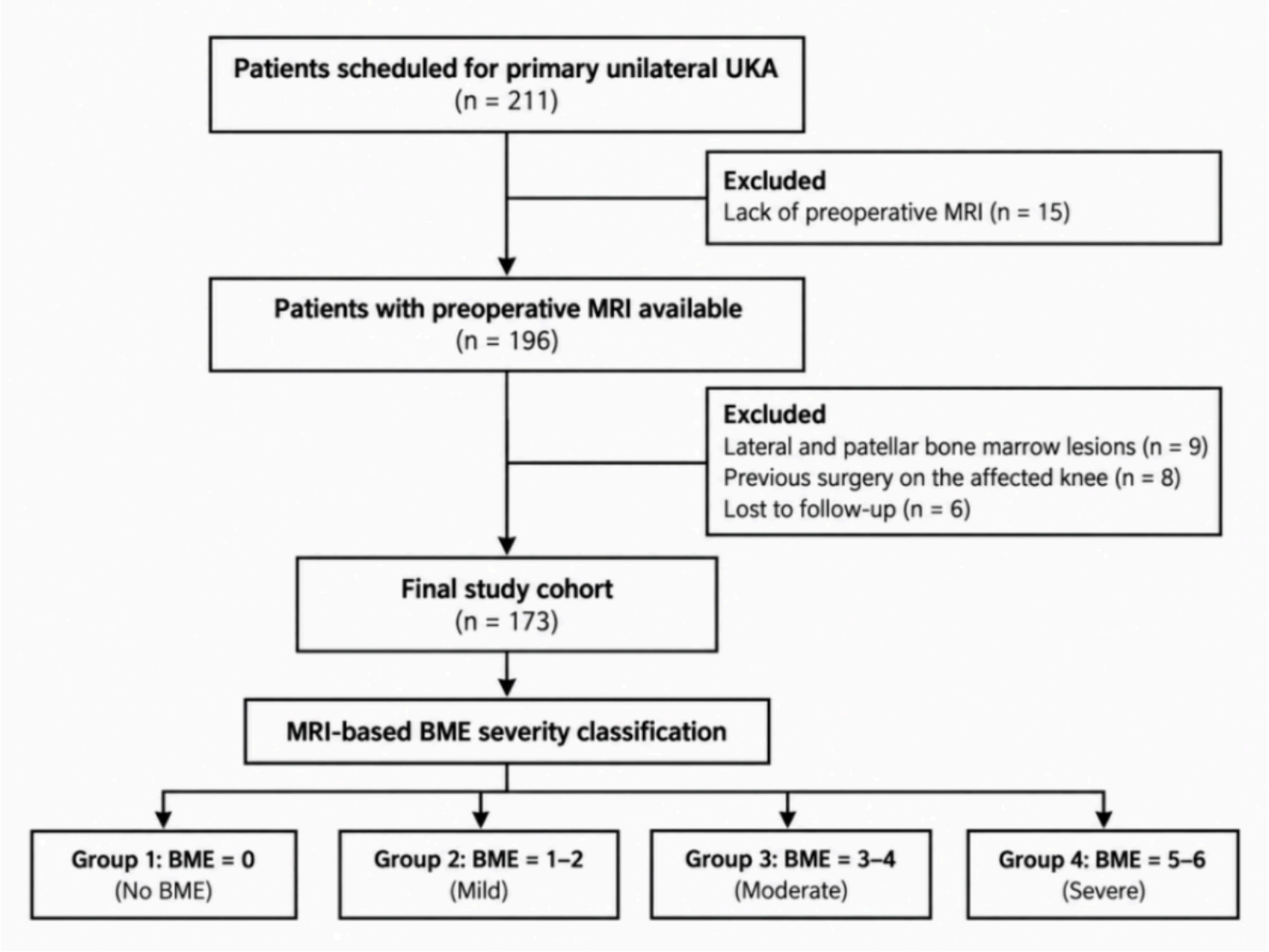


Figure 1

Patient screening and classification by preoperative medial BML severity.



Figure 2

Example of a medial MRI BML assessment: medial femoral score 3 and medial tibial score 3, resulting in a composite score of 6 (severe category).

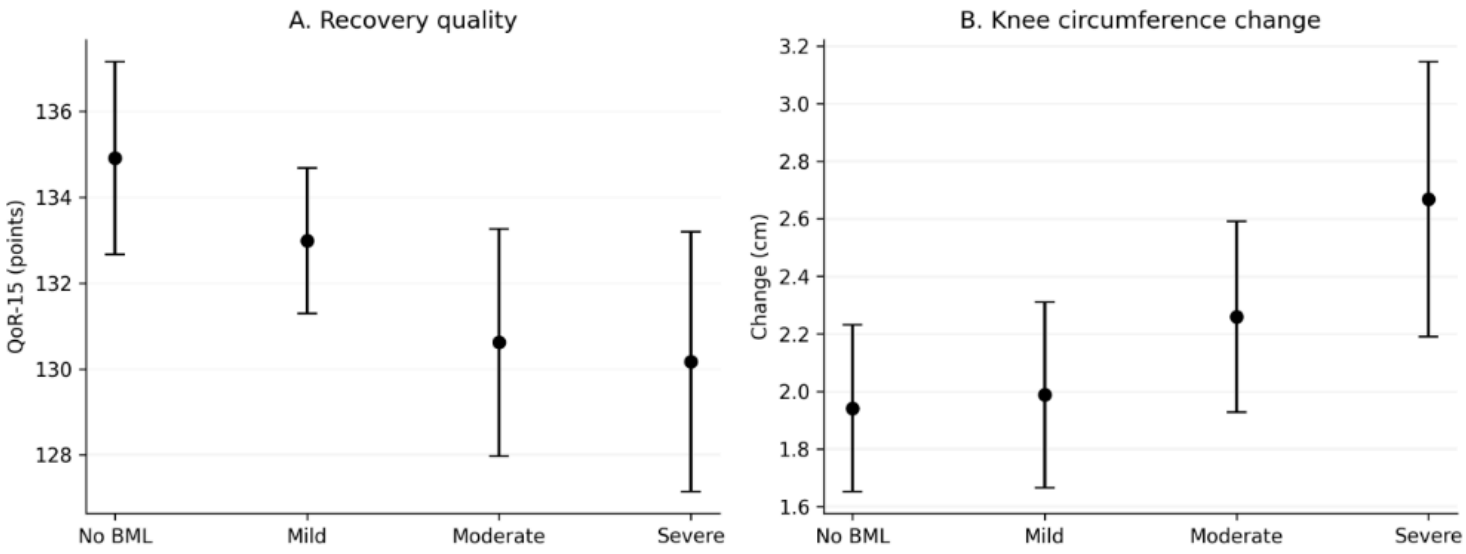


Figure 3

Mean discharge QoR-15 (A) and change in knee circumference (B), with 95% confidence intervals.

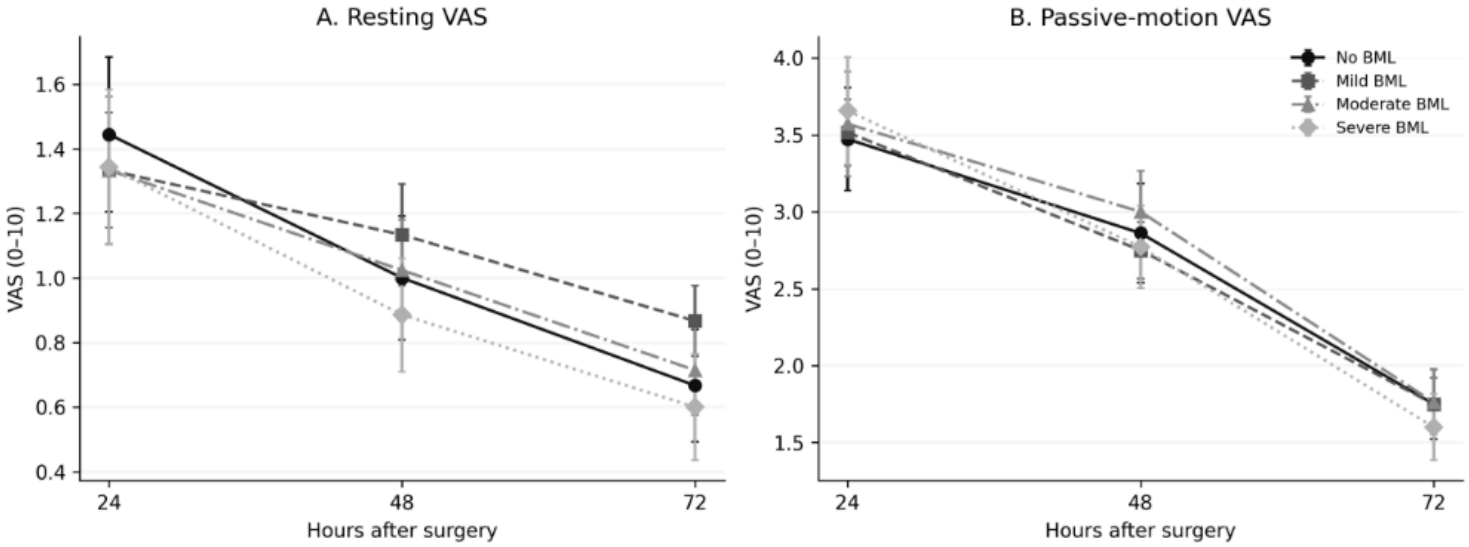


Figure 4

Mean postoperative resting and passive-motion VAS at 24, 48, and 72 hours, with 95% confidence intervals.

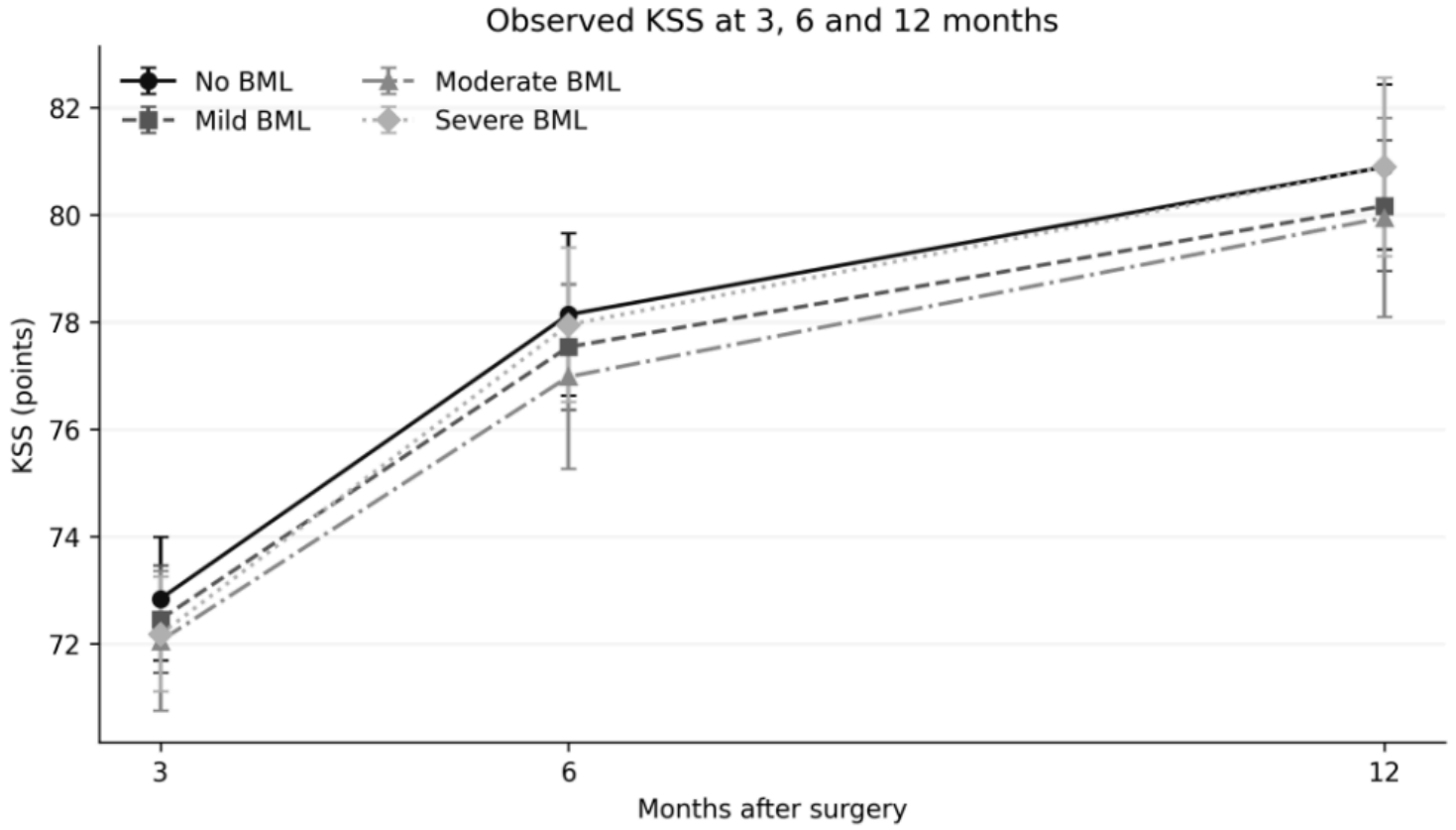


Figure 5

Descriptive group mean Knee Society Scores at 3, 6, and 12 months, with 95% confidence intervals.

Supplementary Files

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