

Association of Preoperative Subchondral Bone Marrow Oedema with Outcomes after Lateral Unicompartmental Knee Arthroplasty

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ABSTRACT

Objective: To determine whether the presence of preoperative subchondral bone marrow oedema (SBME) is associated with inferior outcomes after lateral unicompartmental knee arthroplasty (LUKA).

Study Design: Descriptive study.

Place and Duration of the Study: Department of Orthopaedic Surgery, Chongqing Orthopaedic Hospital of Traditional Chinese Medicine, Chongqing, China, from January 2019 to June 2022.

Methodology: Data on patients treated with LUKA were obtained from the Medical Registry Database. Two groups were made based on the presence and absence of SBME on preoperative magnetic resonance imaging (MRI). The visual analogue scale (VAS), American Knee Society Scores (AKSS), and rate of patient satisfaction were compared between the two groups.

Results: A total of 20 patients treated with LUKA were reviewed. The SBME was present in 9 cases and absent in 11 cases. Patients with SBME had inferior scores at preoperative evaluation and at 1, 3, and 6 months postoperatively. However, there was no significant difference between the groups at the 12-month follow-up. Eight (88.9%) patients with SBME were satisfied with the LUKA surgery versus 9 (81.8%) patients without SBME, showing no significant differences between groups.

Conclusion: Presence of preoperative SBME is associated with inferior functional outcomes after LUKA within six months of follow-up.

Key Words: Bone marrow, Oedema, Knee, Arthroplasty, Outcome, Patient satisfaction.

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INTRODUCTION

Subchondral bone marrow oedema (SBME) is frequently detectable with an estimate of 50% in symptomatic knee osteoarthritis.¹ Regardless of multifactorial aetiology, SBME presents to be a potential source of extra-articular pain.² On magnetic resonance image (MRI) scan, SBME is characterised by an increased signal intensity on T2-weighted fat-suppressed sequences.^{3,4} As knee osteoarthritis has been increasingly surgically treated with total knee arthroplasty (TKA), unicompartmental knee arthroplasty (UKA), and medial opening-wedge high tibial osteotomy (MOWHTO), the association of SBME with outcomes after these surgeries has been widely investigated. However, the implication of SBME on postoperative outcomes differs among various surgical interventions.⁵⁻⁸

Given that lateral unicompartmental knee arthroplasty (LUKA) is relatively rarely performed, to the best of the authors' knowledge, there is still no study assessing the influence of preoperative SBME on outcomes after LUKA. Thus, this study was conducted aiming to clarify the association between the presence of preoperative SBME and functional outcomes following LUKA.

METHODOLOGY

This descriptive study was approved by the Institutional Review Board of Chongqing Orthopaedic Hospital of Traditional Chinese Medicine. Exemption for written informed consent was obtained for this study.

The Medical Registry Database of the institution was used for identifying the eligible patients. All patients who underwent LUKA between January 2019 and June 2022 were screened. Exclusion criteria were patients with prior surgery, concurrent surgery (i.e., ligament and meniscus procedures), preoperative MRI being absent or performed > three months before surgery, and follow-up duration less than 12 months.

Preoperative SBME was identified on a 3.0-T MRI. All plane (sagittal, coronal, and axial cuts) and sequences were

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assessed on the Picture Archiving and Communication System. SBME was defined as an increased signal in the bone marrow on short tau inversion recovery (STIR) sequences. Patient with SBME was defined as any detected SBME in the lateral compartment (lateral condyle of femur, tibia or both). The authors did not score the SBME volume in line with any grading systems. Based on the presence and absence of SBME, enrolled patients were classified into two groups. In the hospital, only fixed-bearing UKA was performed for lateral knee osteoarthritis or osteonecrosis. Outcome variables consisted of the visual analogue scale (VAS) and the American Knee Society Score (AKSS) at 1, 3, 6 and 12 months of follow-up. At postoperative 12 months, the rate of patient satisfaction was compared between the groups.

The intention-to-treat principle was used for missing data. The Chi-square test or Fisher's exact test was used for categorical variables. Continuous data were tested for normality using the Shapiro-Wilk test. Continuous variables were expressed as mean and SD, and categorical variables were expressed as counts and percentages. For data matching normal distribution, a two-sample t-test was used to detect statistical differences between groups. Mixed effects modelling was used to analyse repeated measures (VAS scores and AKSS). The authors used the SPSS software (version 25.0 SPSS Inc., Chicago, IL, USA) to perform statistical data analysis. The differences between groups were presented with 95% confidence intervals. A p-value of 0.05 was considered significant. The authors produced statistical figures with the use of GraphPad Prism software version 9.5.1.

RESULTS

This study enrolled 20 patients who underwent LUKA for knee osteoarthritis or osteonecrosis. The SBME prior to surgery was present in 9 patients and absent in 11 patients (Table I). Among 9 patients with SBME, there were 6 (66.7%) cases of SBME in the femur and 7 (77.8%) in the tibia. No significant differences were noted in demographics between the two groups. All patients completed a minimum follow-up of 12 months. Patients with SBME showed significantly worse preoperative VAS scores and AKSS than patients without SBME (VAS mean difference = 1.953, 95% CI 1.308 to 2.596, $p < 0.001$) (AKSS MD = -9.696, 95% CI -15.613 to -3.781, $p = 0.003$). From baseline to postoperative 1, 3 and 6 months of follow-up, both groups had substantial improvement in VAS scores and KSS, with comparable changes between groups, and there were significant between group differences at each follow-up time (all $p < 0.05$). However, at postoperative 12 months, these scores showed no significant differences. Pain and functional assessment were displaced in Figure 1 (a and b). At the follow-up of 12 months, 8 (88.9%) patients with SBME were satisfied with the LUKA surgery compared to 9 (81.8%) patients without SBME. There were no significant differences in satisfaction rate between groups.

Table I: Comparison of demographic characteristics between groups with and without SBME.

Group	With SBME (n = 9)	Without SBME (n = 11)	p-value
¹ Mean (SD) age (years)	66.78 (5.31)	65.09 (4.72)	0.462
² Female	7 (78%)	10 (91%)	0.566
² Left knee	5 (56%)	3 (27%)	0.362
³ Mean (SD) body mass index (kg/m ²)	27.88 (1.56)	26.89 (2.05)	0.251

¹Data are presented as mean (SD) and compared by t-test; ²Data are presented as counts and percentages and compared by Chi-square test or Fisher's exact test. SBME: Subchondral bone marrow oedema.

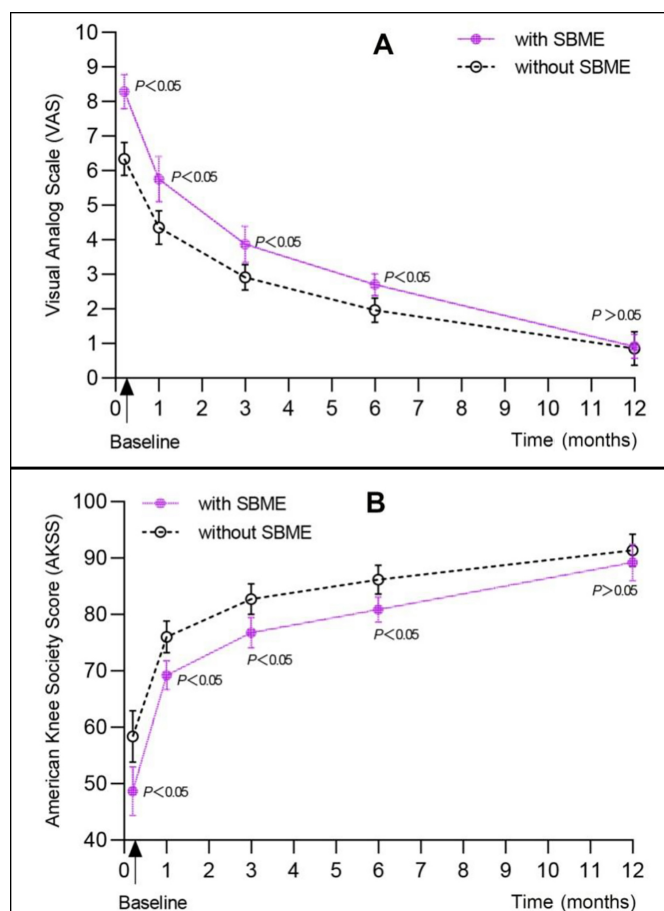


Figure 1: Pain and functional assessment at baseline, one, three, six and 12 months of follow-up. (A) Pain score assessment by visual analogue scale (VAS) ranging from 0 to 10 points; (B) Functional assessment by American Knee Society Score (AKSS) ranging from 0 to 100 points. SBME: Subchondral bone marrow oedema.

DISCUSSION

The prevalence of bone marrow oedema accounts for 13 to 57% of the general population older than 40 years of age.⁹ However, the aetiology and pathogenesis of SBME remain ambiguous. Multiple conditions may be the sources of SBME on MRI.¹⁰ Based on the underlying mechanisms, SBME has been categorised into ischemic, reactive, and mechanical bone marrow oedema. In patients with knee osteoarthritis, the formation of SBME involves a component of limb malalignment, meniscal lesions, cartilage attrition, and microfracture.¹ For the affected compart-

ment, a spectrum of underlying mechanisms may coexist, that gradually leads to overloaded stresses between two opposing joint surfaces.¹¹ Although one study found that edematous specimens from TKA appeared predominantly normal in a histologic examination, in response to increased stresses, the subchondral bone marrow may yield increased intraosseous pressures, decreased vascular perfusion, and inflammatory disorders, finally generate pain in knee osteoarthritis.¹² Cai *et al.* conducted a study and concluded that the presence and size of bone marrow lesion on MRI was significantly associated with the severity of pain in patients with knee osteoarthritis.^{13,14} In addition to tenderness on the affected site, the confirmation of SBME was mainly based on MRI, with decreased signal intensity on T1 imaging with corresponding regions of increased signal intensity on T2 imaging.¹⁵ For most SBMEs, the symptom and radiological presence often resolve with no to minimal intervention. Additionally, high tibial osteotomy, core decompression, and subchondroplasty could be alternatives for chronic SBME treated surgically.^{10,16}

In diverse knee surgeries, the implication of SBME on postoperative outcomes varies substantially. Kim *et al.* conducted a cohort study enrolling 136 patients with knee osteoarthritis undergoing MOWHTO. Within one year after surgery, worse clinical outcomes were found to be associated with the extent and intensity of preoperative SBME.⁸ However, in another study by Yang *et al.*, no correlation was found between preoperative SBME severity and clinical outcomes following MOWHTO.¹⁷

For patients treated with UKA, there was no association of preoperative SBME with postoperative clinical outcomes and 10-year survival rates.⁷ A study of 174 medial UKA patients showed no correlation between chronic SBME and inferior outcomes.¹⁸ Jacobs *et al.* analysed 71 patients undergoing either medial UKA or TKA and demonstrated that the presence of preoperative SBME impacted differently on UKAs and TKAs. In the UKA group, patients with SBME achieved worse pain scores and lower satisfaction than patients without SBME. However, in the TKA group, satisfaction showed no difference between patients with and without tibial SBME.⁵ Given the influence of preoperative SBME on clinical outcomes exhibited substantial heterogeneity in HTO, UKA, and TKA surgeries, potential factors affecting prognosis may involve corrected malalignment, decreased intraosseous pressures, and removal of the inflammatory entity.¹⁰

In the current study, the finding that patients with SBME had worse preoperative pain scores than patients without SBME was consistent with previous studies.⁵ A proposed explanation was that the pain in the osteoarthritic knee may be generated from both extra- and intra-articular pathology. For patients with SBME, the pain was enhanced by subchondral nociceptors.² However, LUKA is a procedure replacing intra-articular lesions and could correct the malalignment to pre-degeneration status within a limited range.^{19,20} Theoretically, it is ineffective in relieving extra-articular pain in short-term follow-up. In this study, although the improvement in VAS scores was significant

in both groups from baseline to postoperative six months, patients without SBME still achieved better recovery than those with SBME during follow-up of six months. However, the difference was no longer sustained at 12 months, indicating that the SBME gradually got resolved following the surgery of LUKA. The comparable satisfaction rate between the two groups validated the inference.

This study had some limitations. First, this research was a retrospective cohort study with selection bias. Second, as LUKA had not been widely performed at the study centre, the sample size was relatively small, which might have reduced the power of statistical analysis. Third, no measurements and subgroup analyses were carried out on extent and degree of SBME. Further research with more cases is essential to make a validated conclusion.

CONCLUSION

Presence of preoperative SBME is associated with inferior functional outcomes after LUKA within six months of follow-up, which can provide crucial information about the expected outcomes for both LUKA patients and practitioners.

ETHICAL APPROVAL:

The Ethics Committee of Chongqing Orthopaedic Hospital of Traditional Chinese Medicine considered this study ethically exempted because it was a retrospective case series study and used only raw data that was completely de-identified and anonymous.

PATIENTS' CONSENT:

Due to retrospective nature of the study, explicit consent of the patients was not required. Only raw data was used that was completely de-identified and anonymous.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

QJ: Formal analysis, data curation, writing original draft, and reviewing.

XB: Data curation and writing original draft.

YD: Resources, supervision, drafting, and reviewing of the manuscript.

HX: Conceptualisation, methodology, drafting and revising of the manuscript.

All authors approved the final version of the manuscript to be published.

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