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Development of a diagnostic scoring system for gouty arthritis of the knee: A retrospective case–control study

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ABSTRACT

Background: Gouty knee arthritis (GKA) is a frequent yet often under-recognised cause of knee pain, especially where synovial crystal analysis or advanced imaging is not readily available. This study aimed to design and validate a practical scoring system to aid the diagnosis of GKA in patients presenting with knee pain, by identifying key associated risk factors and supporting earlier clinical recognition.

Methods: A retrospective case-control study was conducted involving 77 adults experiencing knee pain, with 38 cases of GKA and 39 controls. Risk factors for GKA were identified and analyzed through statistical methods to develop a predictive scoring system.

Results: The analysis revealed several key risk factors associated with GKA. Older age showed a trend toward higher likelihood of GKA in univariable analysis (odd ratio (OR) = 1.08, 95% confidence interval (CI): 0.96–1.21), whereas in multivariable analysis only higher serum uric acid levels remained an independent predictor of GKA. Elevated serum uric acid levels were another strong predictor, with those having higher uric acid levels showing 2.48 times higher likelihood of developing GKA (OR = 2.48, 95% CI: 1.29-4.77). On the receiver operating characteristic (ROC) analysis, gender and history of medication did not show any discrimination towards GKA. The scoring system developed from variables such as age, serum uric acid, leukocyte count, erythrocyte sedimentation rate, periarthricular tophi, history of chronic diseases, history of alcohol consumption, and knee joint bilaterality showed excellent diagnostic performance. Additionally, the area under the curve (AUC) in the ROC analysis was 0.969 (0.933-1.000), which indicates a high level of accuracy in predicting GKA. When compared to traditional diagnostic method such as serum uric acid level (AUC = 0.938), the predictive model was superior.

Conclusion: The newly developed scoring system offers an effective, non-invasive method for early detection of GKA, potentially improving clinical management and patient outcomes. For rehabilitation and physiotherapy practice, earlier recognition of gouty knee using this non-invasive score may support appropriate protection during inflammatory flares, guide progression of loading programmes, and help prioritize rheumatology or orthopaedic referral in patients with knee pain.

Keywords: gouty arthritis of the knee, diagnostic tool, scoring system, risk factors.
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INTRODUCTION

Knee pain is among the most common musculoskeletal complaints affecting people across various age groups, especially the elderly. Epidemiological data suggest that approximately 25% of adults experience knee pain at some point in their lives, leading to impaired daily activities, decreased quality of life, and potential disability.[1] The etiology of knee pain is multifactorial, encompassing post-traumatic injuries, sports-related damage, infections, arthritis, and malignancies. Additionally, risk factors such as obesity, lifestyle habits, and aging contribute significantly to the likelihood of developing knee pain.[2]

Recent studies have highlighted the role of crystal deposits in the degeneration of articular cartilage, with calcium pyrophosphate dihydrate and monosodium urate (MSU) crystals accelerating cartilage degradation and inflammatory responses. Notably, calcium-containing crystals, such as calcium pyrophosphate dihydrate, have been detected in synovial fluid specimens from patients with knee arthritis, accelerating cartilage degradation.[3,4] Furthermore, MSU crystal deposition not only triggers acute inflammatory arthritic episodes but also induces a broader inflammatory reaction characterized by elevated production of degradative enzymes and proinflammatory mediators, hastening cartilage deterioration and leading to secondary osteoarthritis.[5,6] In this study, the authors focused specifically on gouty arthritis of the knee driven by MSU crystal deposition. In contrast, calcium pyrophosphate deposition (CPPD) chondrocalcinosis of the knee represents a distinct crystal arthropathy with different imaging and clinical patterns.

Gouty knee arthritis (GKA) represents a chronic inflammatory joint condition marked by MSU crystal accumulation within the synovial fluid or cartilage of the knee joint. Its clinical manifestations frequently mimic those of osteoarthritis and rheumatoid arthritis, complicating accurate diagnosis and often resulting in delayed or inappropriate treatment.[7,8] Gout arthritis is typically considered a peripheral joint disease, and there remains a lack of sufficiently sensitive imaging techniques for early and accurate detection of gouty changes in the knee.[9]

From a rehabilitation perspective, distinguishing gouty knee from purely degenerative or mechanical causes of pain is essential for safely prescribing exercise. Early, non-invasive identification of GKA can prompt a protection phase during acute flares, avoidance of excessive joint loading, and more timely introduction of progressive strengthening and functional training once inflammation is controlled, thereby optimising recovery and preventing. Given these challenges, this study aims to identify key risk factors associated with GKA and develop a risk prediction scoring system to facilitate early diagnosis. Such a tool could promote timely, appropriate management, improve patient outcomes, prevent progressive joint damage, and reduce the long-term healthcare costs related to advanced interventions such as arthroplasty.

METHODS

Study Design and Setting

This research employed a retrospective observational analytic design using a nested case-control study framework with a cross-sectional approach. The study aimed to identify risk factors and develop a predictive scoring system for GKA detection in adults presenting with knee pain. Data were collected from medical records between July 2022 and June 2025. The research was conducted at Makassar.

Study Population and Subjects

The study population included adult patients aged 30 to 70 years who experienced acute or chronic knee pain and underwent knee arthroscopy in the specified period. Eligible subjects were selected based on inclusion and exclusion criteria. Inclusion criteria were male and female patients aged 30-70 with knee pain who had knee arthroscopy with complete clinical, laboratory, and radiological data available. Exclusion criteria included systemic autoimmune diseases, active knee joint infections, major knee trauma, previous knee surgery on the same knee, incomplete medical records, advanced osteoarthritis (Kellgren-Lawrence grade 3 or 4), and non-inflammatory joint pathology detected arthroscopically. Both cases and controls were drawn consecutively from the same arthroscopy cohort, with GKA diagnosed by arthroscopic evidence of MSU deposition and non-GKA knees serving as controls.

Sample Size and Sampling

This study uses total sampling, meaning all adult patients with knee pain who meet the inclusion criteria and don't meet the exclusion criteria during the study period will be included. This approach ensures that data is gathered from all eligible patients, providing a comprehensive and consistent understanding of knee pain. It allows for uniform data collection and ensures a broad range of patients are included, giving valuable insights into the condition. A nested case–control design with total consecutive sampling was used, and no individual matching was performed.

Data Collection Instruments and Variables

Data were extracted from medical records using structured forms capturing demographics (age, gender, and body mass index), clinical history (acute/chronic knee pain, unilateral involvement, comorbidities, alcohol use, medication history), laboratory results (serum urate level, leukocyte count, erythrocyte sedimentation rate), radiology (osteoarthritis grading), and arthroscopic findings (presence of monosodium urate crystals). Diagnosis of GKA was confirmed by arthroscopic evidence of urate crystal deposition.

Research Procedures

After obtaining ethical approval from the Universitas Hasanuddin Medical Ethics Committee with registered number: 473/UN4.6.4.5.31/PP36/2024, researchers accessed and screened patient records. Eligible cases and controls were identified and data systematically recorded. Differences between groups were analyzed to identify potential predictive factors for GKA. The eligibility screening and data abstraction followed uniform criteria for both groups to minimise spectrum/selection bias

Data Analysis

Data were compiled in Microsoft Excel and analyzed with SPSS software. Descriptive statistics described subject characteristics. Bivariate analyses using Chi-square or Fisher's exact test for categorical variables and t-test or Mann-Whitney U test for continuous variables were performed to identify factors associated with GKA. Variables with p-values < 0.25 entered multivariate logistic regression to determine independent predictors. Regression coefficients were transformed into weighted scores, combined into a predictive scoring system. The scoring system's diagnostic performance was evaluated using receiver operating characteristic (ROC) curve analysis and Youden's index to determine optimal cut-offs point.

RESULTS

In this study, a scoring system was developed to predict gouty knee arthropathy (GKA) using clinical and laboratory risk factors. This study included 77 subjects (38 cases and 39 controls) as shown in **Table 1**. The median age of GKA cases was 57.5 years (range 33-70), older than controls with a median age of 41 years (range 28-65). Males were more prevalent among cases (41.6%) compared to controls (20%). The mean body mass index was 23.82 kilogram per meter squared (kg/m^2) for cases and 22.48 kg/m^2 for controls. Mean serum uric acid level was notably higher in cases at 9.24 milligram per deciliter (mg/dL) versus 4.81 mg/dL in controls, indicating hyperuricemia's strong association with GKA. Other inflammatory markers, such as leukocyte count (12,344 cells/µL in cases vs 7,823 in controls) and erythrocyte sedimentation rate (22.66 millimeters per hour (mm/h) in cases vs 10.79 mm/h in controls) were elevated in the GKA group.

The presence of periarticular tophi, history of chronic diseases, alcohol consumption, and drug use were more frequent in controls than cases.

In the bivariate analysis, variables such as age (*p-value* <0.001), gender (*p-value* = 0.002), serum uric acid (*p-value* < 0.001), leukocyte count (*p-value* < 0.001), ESR (*p-value* = 0.001), periarticular tophi (*p-value* < 0.001), history of chronic diseases (*p-value* < 0.001), history of alcohol consumption (*p-value* = 0.005), history of drug use (*p-value* < 0.001), and joint involvement (*p-value* = 0.001) showed statistically significant associations with GKA. Notably, body mass index did not show significant relationships with GKA in this analysis (*p-value* of 0.075 and 0.095, respectively).

The multivariate logistic regression further refined the predictors as shown in **Table 2**. Serum uric acid remained the only statistically significant independent predictor for GKA with an adjusted odds ratio (OR) of 2.48 (95% CI 1.29–4.77, p=0.007), confirming that each unit increase in serum uric acid nearly doubles the risk of developing GKA. Other factors including age, gender, leukocyte count, ESR, tophi presence, chronic disease, alcohol consumption, drug use, and joint involvement had no significant independent association when adjusted

Table 1. Subject characteristics and bivariate analysis

Variable	Cases (n = 38)	Control (n = 39)	*P*-value
Age (years), median	57.5 (33-70)	41 (28-65)	<0.001
Gender, n (%)			0.002
Male	32 (41.6)	20 (26.0)	
Female	6 (7.8)	19 (24.7)	
Body Mass Index (kg/m^2), mean ± SD	23.82 ± 3.21	22.48 ± 3.26	0.075
Serum uric acid levels (mg/dL), mean ± SD	9.24 ± 2.84	4.81 ± 1.42	<0.001
Leukocyte count (cells/µl), mean ± SD	12,344.74±4,362.64	7,823.85± 1,960.5	<0.001
Erythrocyte sedimentation rate (mm/h), mean ± SD	22.66 ± 20.0	10.79 ± 9.54	0.001
Periarticular tophi, n(%)			<0.001
Yes	20 (26.0)	3 (3.9)	
No	18 (23.4)	36 (46.8)	
History of chronic diseases, n(%)			<0.001
Yes	27 (35.1)	7 (9.1)	
No	11 (14.3)	32 (41.6)	
History of alcohol consumption, n(%)			0.005
Yes	17 (22.1)	6 (7.8)	
No	21 (27.3)	33 (42.9)	
History of drug use, n(%)			<0.001
Yes	21 (27.3)	5 (6.5)	
No	17 (22.1)	34 (44.2)	
Joint involvement, n(%)			0.001
Unilateral	21 (27.3)	35 (45.5)	
Bilateral	17 (22.1)	4 (5.2)	

Cells/µl, cells per microliter; kg/m^2, kilogram per meter squared; mg/dL, milligram per deciliter; mm/h, milimeter per hour; n, number of participants; SD, standard deviation.

Table 2. Multivariate analysis of risk factors associated with gouty knee arthritis

Variable	Cases (n = 38)	Control (n = 39)	OR (95% CI)	P-value
Age (years old), median	57.5 (33-70)	41 (28-65)	1.08 (0.96-1.21)	0.230
Gender, n (%)				
Male	32 (41.6%)	20 (26)	0.79 (0.77-8.20)	0.846
Female	6 (7.8%)	19 (24.7)		
Serum uric acid levels (mg/dl), mean ± SD	9.24 ± 2.84	4.81 + 1.42	2.48 (1.29-4.77)	0.007*
Leukocyte count (cells/µl), mean ± SD	12,344.74 + 4,362.64	7,823.85 + 1,960.5	1.00 (1.00-1.001)	0.316
Erythrocyte sedimentation rate (mm/h), mean ± SD	22.66 + 20.0	10.79 + 9.54	1.07 (0.95-1.21)	0.316
Periarticular tophi, n(%)	20 (26.0)	3 (3.9)	0.89 (0.09-8.36)	0.924
History of chronic diseases, n(%)	27 (35.1)	7 (9.1)	0.89 (0.05-17.49)	0.938
History of alcohol consumption, n(%)	17 (22.1)	6 (7.8)	1.03 (0.76-14.05)	0.980
History of drug use, n(%)	21 (27.3)	5 (6.5)	2.76 (0.16-48.57)	0.487
Joint involvement, n(%)				
Unilateral	21 (27.3)	35 (45.5)	1.89 (0.23-15.5)	0.555
Bilateral	17 (22.1)	4 (5.2)		

Cells/µl, cells per microliter; kg/m^2, kilogram per meter squared; mg/dL, milligram per deciliter; mm/h, milimeter per hour; n, number of participants; OR, odd ratio; SD, standard deviation.

for other variables, indicating serum uric acid as the primary driver in this predictive model.

Prior to developing the scoring system, each potential predictive variable underwent Receiver Operating Characteristic (ROC) curve analysis to assess its diagnostic accuracy for distinguishing GKA cases from controls.

Serum uric acid level demonstrated outstanding discriminative power with an Area Under the Curve (AUC) of 0.938 (*p-value* < 0.001), affirming it as the strongest single predictor. The history of chronic diseased also showed good diagnostic accuracy, with an AUC of 0.766 (*p-value* < 0.001). Leukocyte count had good predictive value with an AUC of 0.838 (*p-value* < 0.001), while ESR had fair accuracy (AUC 0.757, *p-value* < 0.001). Age exhibited moderate diagnostic ability with an AUC of 0.771 (*p-value* < 0.001). Periarticular tophi, joint involvement, and history of alcohol consumption yielded lower but statistically significant AUC values of 0.725 (*p-value* = 0.001), 0.672 (*p-value* = 0.009), and 0.647 (*p-value* = 0.027), respectively.

In contrast, variables like gender presented low AUC values below 0.600 and history of drug use was not statistically significant (*p-value* = 0.06). These findings indicated limited discriminatory power for these variables. Consequently, gender and history of drug use, despite showing some initial associations, were excluded from the final multivariate predictive model due to their poor ROC performance and lack of independent predictive value. This selective approach ensured the scoring system incorporated only variables with strong and clinically meaningful diagnostic accuracy, enhancing its reliability and utility in predicting GKA.

The retained variables for the scoring system included serum uric acid level, periarticular tophi, ESR, leukocyte count, age, history of chronic disease, joint involvement, and alcohol consumption, each contributing to a robust model with clear diagnostic relevance. Each predictor was then weighted based on its logistic regression coefficient converted into a point score, with serum uric acid >6.5 mg/dL receiving the highest score of 3 points due to its strong predictive value.

Table 3. Scoring system for gouty knee arthritis predictor

Variables	Cut-off	Point
Age	≥ 41.5 years	1
Serum Uric Acid Levels	≥ 6.5 mg/dL	3
Leukocyte count	≥ 9,235 cells/µL	1
ESR	≥ 8.5 mm/h	1
Periarticular tophi	Yes	1
History of chronic diseases	Yes	1
History of alcohol consumption	Yes	1
Joint Involvement	Unilateral Bilateral	0 1
Total Score		0-10

Cells/µl, cells per microliter; mg/dL, milligram per deciliter; mm/h, milimeter per hour

Table 4. Scoring system interpretation and analysis

Total Score	Sensitivity	Specificity	Clinical Interpretation
1-3	100%	<75%	Weak suspicion
4-6	82-97%	85-95%	Moderate suspicion
7-10	<75%	>95%	Strong suspicion

Alcohol consumption, despite showing less statistical impact, was assigned a score of 1 for its contributory role. Joint involvement had minimal weighting (0 for unilateral, 1 for bilateral). Other predictors like leukocyte count and tophi were also incorporated based on their univariate significance. The scoring system developed was shown in **Table 3**.

Receiver Operating Characteristic (ROC) curve analysis evaluated the discriminative ability of the scoring system. The area under the ROC curve (AUC) for the final scoring model was 0.969 (95% CI: 0.933–1.000), signifying excellent accuracy in distinguishing GKA patients from controls. As shown in **Table 4** the Cut-off points in the scoring system delineated three suspicion categories for clinical use: weak suspicion (score 1-3) with 100% sensitivity but less than 75% specificity, useful to catch all potential cases at the expense of false positives; moderate suspicion (score 4-6) with balanced sensitivity (82-97%) and specificity (85-95%), suitable for clinical decision-making and follow-up; and strong suspicion (score 7-10) offering specificity of 95% but somewhat lower sensitivity (75%), best for confirming diagnoses.

Overall, this predictive scoring system provides a practical and reliable tool to assist early identification of GKA in primary care settings. It is built predominantly around serum uric acid levels, the key driver, but integrates other clinical and lifestyle factors to enhance diagnostic precision. Such a model can facilitate timely treatment initiation and potentially improve patient outcomes by stratifying risk efficiently.

DISCUSSION

The predictive scoring system for GKA developed in this study was designed to provide a simple, accurate, and practical diagnostic tool based on significant risk factors. The model was built from a comprehensive analysis of demographic and clinical variables, evaluated through both bivariate and multivariate statistical testing. Factors such as age, serum uric acid levels, ESR, leukocyte count, periarticular tophi, chronic disease history, alcohol consumption, and joint involvement were found to be important predictors and were therefore included in the final scoring system. Each variable was assigned a weight derived from multivariate analysis (B values), which was then converted into a score to reflect its relative contribution to GKA risk. For example, serum uric acid levels above 6.5 mg/dL had the strongest

impact and were therefore assigned the highest score of 3. In contrast, alcohol consumption, although discriminative, had only a small effect and was assigned a score of 1. This weighting system ensures that variables with stronger associations exert greater influence in the overall score, while smaller yet relevant factors are still considered. Importantly, the scoring system does not only rely on biomedical markers such as uric acid and ESR, but also integrates lifestyle and comorbidity factors, including alcohol consumption and chronic disease history. This highlights the multifactorial nature of GKA, which is shaped not only by metabolic and inflammatory pathways but also by individual habits and broader health conditions. By incorporating such variables, the system achieves a more holistic reflection of disease risk.

Age was strongly associated with GKA. Older individuals, particularly those above 50 years, showed a higher risk. Prior studies support that older age is linked to reduced renal clearance of uric acid and cumulative hyperuricemia, contributing to MSU crystal deposition.[10-12] A cross-sectional study found women were typically older than men at gout diagnosis, with greater comorbidity burden.[13] Similarly, studies reported higher serum uric acid level in older populations with osteoarthritis.[14] These findings confirm age as a key determinant, justifying its inclusion in the scoring system. Gender differences were evident in previous studies, with males at greater risk. This aligns with reports that men generally have higher serum uric acid due to hormonal and metabolic factors.[13] Estrogen in premenopausal women also enhances urate excretion, explaining the lower incidence of gout, while postmenopausal women experience increased risk as estrogen declines.[15] But in this study, gender failed to show any discrimination for GKA in ROC analysis hence its exclusion from the scoring system. BMI correlated positively with GKA. Obesity is a known contributor to hyperuricemia and gout via increased urate production and impaired excretion.[13,15] This study found that BMI was not significantly different in cases and controls group. This finding aligns with study from China that BMI was indifferent in patients with GKA.[17] Rather than BMI, it seems that central obesity that cause comorbidities such as diabetes, hypertension, or kidney failure. In the end, these comorbidities increase the risk of hyperuricemia and GKA.

Serum uric acid levels emerged as a major predictor, with higher levels among GKA patients. Hyperuricemia remains the strongest risk factor for gout.[18] Asymptomatic hyperuricemia has been associated with increased knee OA prevalence, although longitudinal data suggest baseline serum uric acid levels may not predict radiographic OA progression.[14,19] Despite these nuances, persistently elevated serum uric acid levels remains central to gout diagnosis and justifies its weight in the scoring model.[20] Serum leukocyte count was higher in GKA cases, reflecting systemic inflammation due to MSU crystal deposition. Prior studies show leukocytosis corresponds with gout activity, supporting its inclusion.[21] ESR was significantly elevated in patients with GKA. ESR is non-specific but useful when interpreted alongside clinical features. Its diagnostic role has been highlighted in distinguishing gout from other inflammatory arthritis.[22-24]

Periarticular tophi proved to be a strong predictor. The presence of visible/palpable tophi indicates chronic urate deposition and advanced disease.[25] Tophi could impact patient's quality of life by causing arthritis, tendon rupture, skin ulcer, and neural dysfunction.[26] Thus, its weighting in our system aligns with established diagnostic frameworks. Chronic comorbid diseases such as hypertension, diabetes, and chronic kidney disease were significantly associated with GKA. These conditions impair urate metabolism and excretion.[19,20] Prior work shows women with gout have higher rates of renal impairment and hypertension than men, reinforcing the need to evaluate comorbidities when predicting GKA.[13] History of alcohol consumption was more frequent in GKA patients. Alcohol accelerates purine metabolism and decreases urate clearance. Beer contains purines that further elevate risk. Lifestyle studies consistently show alcohol intake especially in men as a modifiable risk factor for gout.[27] This justified the inclusion of alcohol intake as a predictor for GKA. Medication history, especially diuretics, was significantly associated with GKA. Thiazide and loop diuretics reduce urate clearance, while immunosuppressants like cyclosporine exacerbate hyperuricemia.[19,20] Previous studies confirm higher diuretic use among women with gout.[13] Including drug history increases clinical relevance, particularly in patients with polypharmacy. Joint involvement was observed as an important clinical feature in patients with GKA. Although it did not emerge as a dominant independent predictor in the multivariate model, it still showed value in distinguishing patients with and without the disease. This aligns with the findings of Girish et al., who reported that joint involvement in gout patients often serves as a meaningful clinical indicator of disease severity, even if it is not always directly linked to progression of GKA.[28] Similarly, Shreyas N demonstrated that bilateral joint involvement was more frequently seen in patients with gout compared to unilateral patterns, underscoring its relevance as a clinical characteristic.[29] In the case of joint involvement, although bivariate analysis showed significant differences, multivariate analysis revealed only a modest effect compared to other variables such as serum uric acid. For this reason, joint involvement was assigned a lower weight, with unilateral involvement scored as 0 and bilateral involvement as 1, recognizing its clinical importance but proportionally less impact in the predictive model.

The scoring system generates a total score ranging from 0 to 10, which is categorized into three levels of diagnostic suspicion: low, moderate, and high. Patients with scores of 1–3 fall into the low suspicion category, which is characterized by 100% sensitivity but specificity below 75%, indicating that further diagnostic confirmation is required in this group. The moderate suspicion category (scores 4–6) demonstrated a more balanced performance, with sensitivity of 82–97% and specificity of 85–95%, making it suitable for identifying patients requiring closer monitoring. The high suspicion category (scores 7–10) had lower sensitivity (<75%) but very high specificity (>95%), meaning that individuals identified in

this group are highly likely to have GKA. The diagnostic performance of this model was confirmed by ROC analysis, which showed an excellent AUC of 0.969 (95% CI: 0.933–1.000), indicating outstanding discriminative ability between patients with and without GKA.

Our findings are consistent with previous attempts to develop predictive scoring systems. Zha et al. proposed a simplified model linking serum uric acid with pro-inflammatory cytokines, while Zhang et al. constructed a risk model incorporating uric acid, gender, and proteinuria, achieving good diagnostic accuracy.[17,30] Merriman et al. emphasized the importance of genetic and biomarker-based approaches, identifying more than 300 loci linked to hyperuricemia and GKA through genome-wide association studies.[31] Yoshida et al. demonstrated the potential of AI-based prediction models using large datasets, though they also noted that clinically based scoring systems remain more practical in routine care.[32] Similarly, Liu et al. developed an ultrasound-based scoring system that showed strong diagnostic accuracy, underscoring the role of imaging in specific contexts.[33] Compared with these approaches, our model stands out by integrating routine clinical and laboratory factors into a simple, accessible system, making it particularly applicable in primary and secondary care where advanced imaging and genetic testing are not always available.

Synovial fluid microscopy for MSU crystals remains the reference standard for gout diagnosis, while ACR/EULAR criteria and imaging modalities such as ultrasound and DECT provide robust classification and diagnostic support.[7-9,16,33] In contrast, the present score is designed as a non-invasive triage aid to identify patients with knee pain who warrant targeted arthrocentesis, imaging, or rheumatology referral, particularly in settings where immediate microscopy or DECT is unavailable. Thus, the score should be viewed as a complement to, rather than a replacement for, established diagnostic pathways.

It should be emphasized that this scoring system is not intended to replace clinical judgment but to complement it. A high score may alert clinicians to the likelihood of GKA and encourage further confirmatory evaluation, while low or moderate scores guide monitoring and follow-up. This approach reflects the practical realities of daily clinical settings, particularly in resource-limited healthcare facilities. By combining demographic, laboratory, clinical, and lifestyle variables, this system provides a more comprehensive and user-friendly tool for risk stratification, supporting timely diagnosis and management of GKA.

This study is limited by its retrospective design, with inherent biases due to reliance on medical record documentation which may be incomplete or inconsistent. The sample size, although sufficient for initial modelling, constrains broad generalizability. The single-center hospital-based recruitment further limits applicability to diverse populations. Prospective, multicenter validation studies are needed to confirm the generalizability and refine cutoff scores of the prediction scoring system.

Future research should focus on larger, prospective cohort studies across multiple healthcare settings to validate and optimize the predictive scoring system. This would provide more robust evidence regarding its applicability in diverse populations. The inclusion of advanced diagnostic imaging techniques, such as dual-energy computed tomography (DECT) or magnetic resonance imaging (MRI), could enhance diagnostic precision and improve the system's calibration, offering a more refined approach to diagnosing GKA. To assess transportability, future multi-centre prospective studies should validate this scoring system across different care settings, including those where rehabilitation services are integral to knee-pain management. Such trials should incorporate patient-centred rehabilitation endpoints, such as pain intensity, functional scores, and time to return to activity, as well as impact measures such as time to correct specialist referral, potential reduction in unnecessary invasive procedures, and safer, earlier initiation of structured exercise programmes in patients appropriately classified as having gouty knee arthropathy

Additionally, longitudinal studies are needed to assess how well the scoring system can track disease progression and evaluate the effectiveness of various treatments. Such studies would provide invaluable clinical insights into the utility of the model over time. Expanding the current system to incorporate biochemical markers, genetic risk factors, and additional lifestyle variables would help improve risk stratification and facilitate more personalized patient care.

CONCLUSION

This study presents a practical, evidence-based scoring tool that integrates clinical, biochemical, and inflammatory markers to facilitate the early diagnosis of gouty knee arthropathy. By improving diagnostic accuracy, this tool can guide timely management, potentially reducing long-term morbidity and healthcare costs associated with advanced disease.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this study. No financial support, personal relationships, or competing interests influenced the design, conduct, analysis, or reporting of this research.

ETHICAL CONSIDERATIONS

The study received ethical clearance from the Faculty of Medicine, Universitas Hasanuddin, Indonesia, with registered number: 473/UN4.6.4.5.31/PP36/2024. Patient confidentiality was maintained by anonymizing data during analysis to prevent any harm or breach of privacy.

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AUTHOR CONTRIBUTIONS

KT led the study conception and design, coordinated data collection, performed the primary data analysis, and drafted the first version of the manuscript. MS and

HY contributed to patient recruitment, clinical assessment, and data acquisition and assisted in interpreting the findings in an orthopaedic context. FH provided methodological input, contributed to the interpretation of results from a microbiological/immunological perspective, and critically revised the manuscript for important intellectual content. IAP provided overall supervision of the project, ensured the clinical and surgical relevance of the study design, and contributed to critical manuscript revision. NR assisted with data management, statistical analysis, and refinement of the tables and figures. All authors reviewed, contributed to, and approved the final version of the manuscript.

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