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Research Article

Radiological Grading and the Functional Status of Primary Osteoarthritic Knee in Pre-Total Knee Replacement: A Cross-Sectional Study in Malaysia

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Abstract

Objectives: This study aims to investigate the correlation of radiographic findings and the functional status of severe primary osteoarthritis (OA) knee in pre-total knee replacement (TKR) patients in Malaysia, a cohort representing the severe end of the OA spectrum

Material and Methods: This study included 100 patients with primary OA who were admitted for total arthroplasty. A cross-sectional study using the knee injury and Osteoarthritis Outcome Score (KOOS) and Kallgren-Lawrence (KL) classification (grading) was conducted at Tuanku Jaafar Hospital, Seremban, Malaysia. The sample size of 85 was calculated using the equation, $N = [(Z\alpha+Z\beta)/C]2 + 3$, and as for the comparison of a continuous variable, ANOVA was used whereby the statistical significance was set at $p < 0.05$. Antero-posterior knee radiographs of the patients were graded according to Kellgren-Lawrence, and functional capacity was evaluated using KOOS.

Results: There was a total of 100 participants with 29 males and 71 females. Most patients were predominantly in the age group of 60-69 (42%) and 70-79 (46%) whereas the least was in the age group of 90-99 (1%). Patients interviewed were multiracial with Malay being 42%, Chinese being 32%, Indian being 25%, and 1% from other races. Characteristics of the patient do not contribute to the total KOOS outcome as all were $p > 0.05$. There was statistical significance between KOOS and KL grading with $p < 0.001$. There was also a correlation between KOOS and KL grading with a correlation coefficient, r of +0.373 showing that as KL grading increases, KOOS becomes worse.

Conclusion: There is a significant, positive association between KOOS and KL grading which determines that higher radiographic severity with a higher KL grade is associated with worse functional status with a higher KOOS score.

Keywords: Knee Injury and Osteoarthritis Outcome Score (KOOS); Osteoarthritis (OA); Malaysia

Introduction

Osteoarthritis (OA) is the most common form of arthritis, affecting an estimated 20% of people over the age of 50 globally [1]. It is a degenerative joint disease primarily affecting the hyaline cartilage [2]. According to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017, the prevalence of OA is expected to increase, posing a growing burden worldwide [1].

The primary clinical symptom of knee OA is pain, but its correlation with radiographic findings remains controversial, as pain is more strongly associated with a patient's quality of life [3]. The Knee Injury and Osteoarthritis Outcome Score (KOOS) is a well-established patient-reported outcome measure used to assess func-

tional status and symptoms following a knee injury. It comprises five subscales: pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life [4].

The plain radiograph is the primary tool for diagnosing OA, and the Kellgren-Lawrence (K-L) grading system, first described in 1957, is the most widely adopted method for radiographic evaluation [2]. Numerous treatment plans for OA aim to minimize symptoms and prevent further functional deterioration [5].

It is crucial to consider the association between function and radiological features before recommending definitive treatment [5]. However, there is no universal consensus on the relationship between these two variables and how it should guide definitive treatment decisions [6].

In Malaysia, there have been a limited number of studies investigating this relationship. Therefore, this study aims to determine the correlation between radiographic findings, using the K-L grading system, and the functional status of pre-operative patients with knee OA, using the KOOS questionnaire. The study provides crucial confirmatory data specifically within the Malaysian OA population hospitalized in an orthopedic ward for total knee replacement (TKR).

Methods

Study design and setting

A cross-sectional study was conducted among adult patients with primary knee OA admitted to Hospital Tuanku Jaafar (HTJ), Seremban, Malaysia, between March 2024 and December 2024. HTJ is a tertiary hospital for the state of Negeri Sembilan, which is a public hospital performing Total Knee Replacement (TKR) surgery. The inclusion criteria for this research were patients with a confirmed clinical diagnosis of primary knee OA, aged over 40 years, and scheduled to undergo primary total knee replacement (TKR) surgery. Patients were excluded if they had secondary knee OA, a history of previous knee surgery on the index knee, were scheduled for revision TKR, or had incomplete data or declined to provide consent.

Study instrument

The functional status of the osteoarthritic knee was evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS), which was developed from the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [4]. The KOOS is a comprehensive instrument that consists of 42 items across five subscales: pain, other symptoms, function in daily living, function in sports and recreation, and knee-related quality of life [4]. In this study, the scores were interpreted with 0 representing the best possible situation and 100 representing the worst [7]. The English version of the KOOS was used for all participants, which has been shown to be reliable and appropriate in the Malaysian population (4).

All participants had a plain, weight-bearing X-ray of both knees in anterior-posterior and lateral views. The X-ray acquisition protocol followed standard departmental guidelines for pre-operative total knee replacement imaging, which included a standing, weight-bearing AP view. The radiographic severity of the OA was evaluated using the Kellgren-Lawrence (K-L) grading system [8]. The K-L classification grades knee radiographs from 0 to 4, with higher grades indicating more severe OA characterized by joint space narrowing, the presence of osteophytes, and subchondral changes [8]. K-L grading was performed by a trained Orthopaedic Specialist and was confirmed by the attending Consultant Orthopaedic Surgeon. The specific flexion angle for the lateral view was not recorded. Inter- and intra-rater reliability for K-L grading was not formally assessed as part of this study, which is acknowledged as a limitation due to the potential for classification variability.

Sample size and sampling

A sample size calculation was performed before the study using standard methods for correlation analysis. Using a significance level of 0.05, power of 80%, and an expected correlation of –0.30 (based on previous literature), the minimum required sample size was estimated to be approximately 85 patients. Our study included 100 patients, which exceeded this requirement and provided sufficient power to detect the expected association between KL grade and KOOS scores.

The sample size was estimated using the equation, N = [(Zα+Zβ)/C]2+3, with a calculated sample size of 85. Convenience sampling was used to recruit study participants from the orthopaedic ward at Hospital Tuanku Jaafar.

The patients were selected from the TKR waiting list with patient's knee with the worst function was chosen for analysis, and a corresponding X-ray was graded using the K-L system. Patients' gender, age, race, occupation, education level, marital status, and monthly income were also collected. This recruitment method introduces potential selection bias.

Statistical analysis

The primary outcome measure was the overall Knee Injury and Osteoarthritis Outcome Score (KOOS). The K-L grading was the primary independent variable. Data were analyzed using IBM Statistics Programme for Social Sciences (IBM SPSS) Version 25. Missing data were minimal, less than 1% and were handled using pairwise deletion for correlation analyses and listwise deletion for ANOVA where appropriate. No imputation methods were used. Descriptive statistics were used for demographic and clinical variables. An independent samples T-test and ANOVA were used to assess the significance of demographic variables on the global KOOS score. A post-hoc test was then performed to identify significant differences between K-L grades. Spearman's Rank Correlation test was used to determine the significance of the correlation between K-L grading and KOOS scores, with a p-value less than 0.05 considered statistically significant. While the effect of individual demographic variables on the global KOOS score was assessed using independent samples T-test and ANOVA, multivariate regression analysis to adjust for potential confounders (e.g., age, sex) was not performed, as the primary objective was to determine the simple correlation between K-L grade and KOOS. Furthermore, crucial clinical factors such as BMI, limb alignment (varus/valgus), symptom duration, and comorbidities were not systematically collected.

Ethics approval and data confidentiality

This research was approved by IMU Joint-Committee on Research & Ethics, International Medical University [4.5/JCM-152/2017], NMRR (ID: NMRR-17-3468-38876). The consent verbal or written was taken from patients before eliciting the questionnaire. The data were de-identified and stored in a password-protected file accessible only to the researchers.

Results

A total of 100 patients admitted for knee surgery participated in this study with 29 males and 71 females. Most patients were predominantly in the age group of 60-69 (42%) and 70-79 (46%) whereas the least was in the age group of 90-99 (1%). Patients interviewed were multiracial with Malay being 42%, Chinese being 32%, and Indian being 25%. More than half of the patients were retired. 31 patients received education up to the primary level. Most of the patients interviewed were married (83%) and fell within the monthly income range of <1000 (42%). Most of the patients were living with their family members (Table 1).

The significance of KOOS according to patients' demographic features are shown in Table 2. After statistical testing through independent t-test (gender) and ANOVA (other demographic features), there were no statistical significance of the demographic features to KOOS (gender, $p = 0.449$; age, $p = 0.568$; race, $p = 0.912$; occupation, $p = 0.745$; education level, $p = 0.153$; marital status, $p = 0.761$; monthly income, $p = 0.098$, cohabitation, $p = 0.235$).The frequency of grades among 100 patients are shown in figure 1.

Table 3 shows the ANOVA of KOOS by KL grading. For Grade I patients, their mean KOOS was 33.8 ± 16.4; Grade II (47.0 ± 18.5); Grade III (52.6 ± 16.3); Grade IV (59.8 ± 16.6). There was overall statistical significance between KL grading to KOOS with a mean of 52.8 ± 17.9 and overall $p < 0.001$. With this, a post hoc test was done to identify the significant difference between each KL grade. From the result, there was a significant difference between KL Grade I to Grade III, $p < 0.025$, and Grade I to Grade IV, $p < 0.001$.

To observe the correlation between KOOS and KL grading, a simple scatter graph was plotted as shown in figure 2. From these, a line of best fit was obtained through the simple scatter graph with a correlation coefficient, r of +0.373 and CI: 0.19 to 0.53. There was statistical significance between KL grading and KOOS with $p < 0.001$.

Table 1: Characteristics of participants.

	Characteristics	Frequency, n (%)
1	Age	
	40-49	3(3.0)
	50-59	23(23.0)
	60-69	42(42.0)
	70-79	46(46.0)
	80-89	5(5.0)
	90-99	1(1.0)
	Total	100(100.0)
2	Gender	
	Male	29(29.0)
	Female	71(71.0)
	Total	100(100.0)
3	Race	
	Malay	42(42.0)
	Chinese	32(32.0)
	Indian	25(25.0)
	Others	1(1.0)
	Total	100(100.0)
4	Occupation	
	Retired	56(56.0)
	Employed	24(24.0)
	Others	20(20.0)
	Total	100(100.0)
5	Education Level	
	Primary	44(44.0)
	Secondary	35(35.0)
	Tertiary	31(31.0)
	Total	100(100.0)
6	Marital Status	
	Single	2(2.0)
	Married	83(83.0)
	Divorced	3(3.0)
	Widow/Widower	12(12.0)
	Total	100(100.0)
7	Monthly Income	
	<1000	42(42.0)
	1001-2000	28(28.0)
	2001-3000	12(12.0)
	3001-4000	9(9.0)
	>4000	9(9.0)
	Total	100(100.0)
8	Cohabitation	
	Family	92(92.0)
	With Carer	1(1.0)
	Alone	7(7.0)
	Total	100(100.0)

Table 2: Analysis of variance (ANOVA) for the KOOS according to the demographic features.

Characteristics	p-values
Age	p = 0.568
Gender	p = 0.449
Race	p = 0.912
Occupation	p = 0.745
Education Level	p = 0.153
Marital Status	p = 0.761
Monthly Income	p = 0.098
Cohabitation	p = 0.235

Table 3: Kellgren-Lawrence (KL) grading of participants.

KL Grading	Frequency, n (%)
I	8(8.0)
II	13(13.0)
III	45(45.0)
IV	34(34.0)
Total	100(100.0)

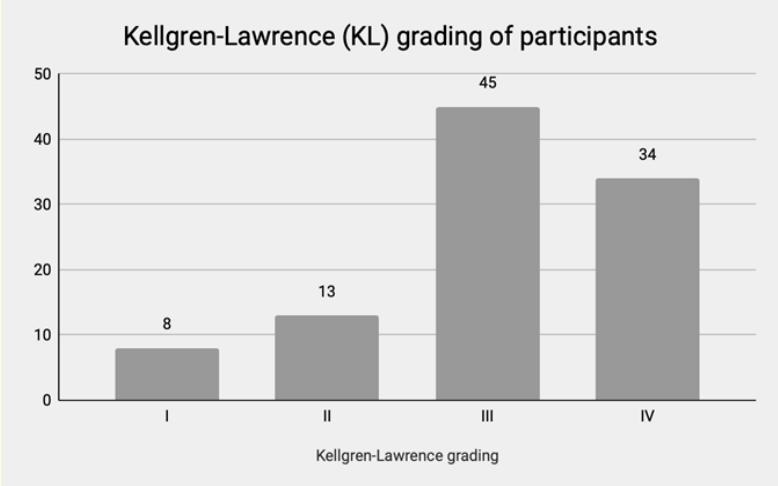

Figure 1: Kellgren-Lawrence (KL) grading of participants.

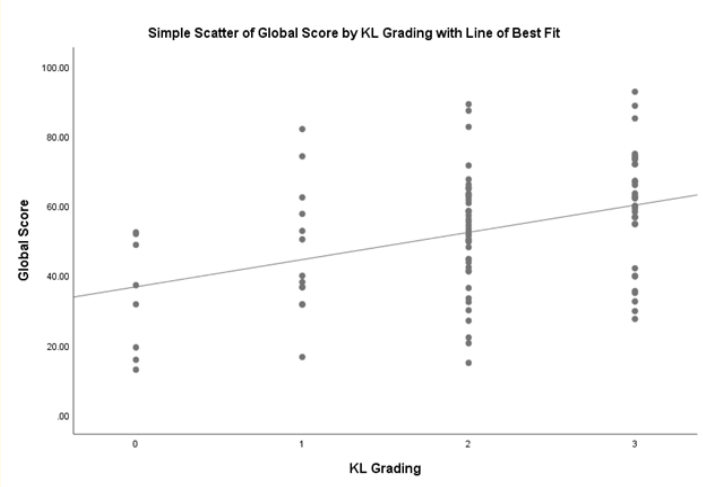

Figure 2: Scatterplot of KOOS by KL Grading with Best Fit Line.

KL Grading	Mean ± SD	p-value*
I	33.8 ± 16.4	
II	47.0 ± 18.5	
III	52.6 ± 16.3	P < 0.001
IV	59.8 ± 16.6	
Total	52.8 ± 17.9	

Table 4: ANOVA for the KOOS according to the KL grading.
*p-value for overall.

Characteristic	Total (n = 100)	KL Grade I (n = 8)	KL Grade II (n = 13)	KL Grade III (n = 45)	KL Grade IV (n = 34)
Age Group, n (%)					
40-49	3 (3.0)	1 (12.5)	1 (7.7)	1 (2.2)	0 (0.0)
50-59	23 (23.0)	3 (37.5)	4 (30.8)	10 (22.2)	6 (17.6)
60-69	42 (42.0)	2 (25.0)	5 (38.5)	20 (44.4)	15 (44.1)
70-79	46 (46.0)	2 (25.0)	3 (23.1)	22 (48.9)	19 (55.9)
80-89	5 (5.0)	0 (0.0)	0 (0.0)	2 (4.4)	3 (8.8)
90-99	1 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.9)
Gender, n (%)					
Male	29 (29.0)	3 (37.5)	4 (30.8)	12 (26.7)	10 (29.4)
Female	71 (71.0)	5 (62.5)	9 (69.2)	33 (73.3)	24 (70.6)
Race, n (%)					
Malay	42 (42.0)	3 (37.5)	5 (38.5)	20 (44.4)	14 (41.2)
Chinese	32 (32.0)	3 (37.5)	4 (30.8)	14 (31.1)	11 (32.4)
Indian	25 (25.0)	2 (25.0)	4 (30.8)	10 (22.2)	9 (26.5)
Others	1 (1.0)	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)
Occupation, n (%)					
Retired	56 (56.0)	3 (37.5)	6 (46.2)	26 (57.8)	21 (61.8)
Employed	24 (24.0)	3 (37.5)	4 (30.8)	10 (22.2)	7 (20.6)
Others	20 (20.0)	2 (25.0)	3 (23.1)	9 (20.0)	6 (17.6)
Education Level, n (%)					
Primary	44 (44.0)	2 (25.0)	4 (30.8)	21 (46.7)	17 (50.0)
Secondary	35 (35.0)	3 (37.5)	5 (38.5)	16 (35.6)	11 (32.4)
Tertiary	31 (31.0)	3 (37.5)	4 (30.8)	14 (31.1)	10 (29.4)
Marital Status, n (%)					
Single	2 (2.0)	0 (0.0)	0 (0.0)	1 (2.2)	1 (2.9)
Married	83 (83.0)	7 (87.5)	12 (92.3)	37 (82.2)	27 (79.4)
Divorced	3 (3.0)	0 (0.0)	0 (0.0)	2 (4.4)	1 (2.9)
Widow/Widower	12 (12.0)	1 (12.5)	1 (7.7)	5 (11.1)	5 (14.7)
Monthly Income, n (%)					
< 1000	42 (42.0)	2 (25.0)	4 (30.8)	20 (44.4)	16 (47.1)
1001-2000	28 (28.0)	3 (37.5)	4 (30.8)	12 (26.7)	9 (26.5)
2001-3000	12 (12.0)	1 (12.5)	2 (15.4)	5 (11.1)	4 (11.8)
3001-4000	9 (9.0)	1 (12.5)	1 (7.7)	4 (8.9)	3 (8.8)
> 4000	9 (9.0)	1 (12.5)	2 (15.4)	4 (8.9)	2 (5.9)
Cohabitation, n (%)					
With Family	92 (92.0)	8 (100.0)	12 (92.3)	41 (91.1)	31 (91.2)
With Carer	1 (1.0)	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)
Alone	7 (7.0)	0 (0.0)	1 (7.7)	3 (6.7)	3 (8.8)
KOOS Score, Mean ± SD	52.8 ± 17.9	33.8 ± 16.4	47.0 ± 18.5	52.6 ± 16.3	59.8 ± 16.6

Table 5: Baseline Characteristics of Study Participants by Kellgren-Lawrence (KL) Grade.

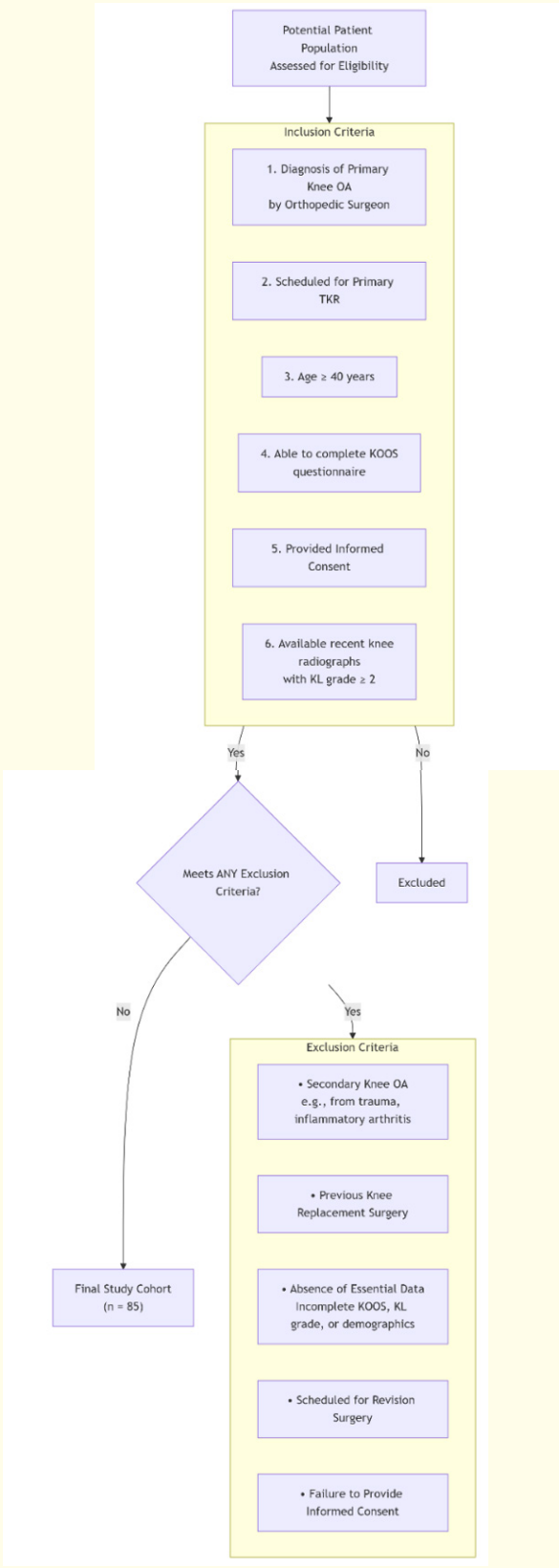

Figure 3: Flow diagram of patient selection.

Discussion

The demographic profile of our study participants, with a predominance of women (71%) and older adults (88%), aligns with the established epidemiology of knee OA [9]. This demographic composition is clinically significant as it reflects the typical patient population seen in orthopedic clinics [10]. Our primary finding of a significant and positive correlation between KOOS and K-L grading suggests that as radiographic severity increases, so too does the patient's perceived functional impairment.

While a direct correlation may not be a novel discovery in itself, its demonstration within our specific Malaysian OA patient population holds significant clinical implications for personalized treatment, as it highlights that a patient's symptomatic and functional state is critical for treatment planning [5]. This understanding helps clinicians avoid decisions based solely on X-ray appearance, which can prevent both overtreatment and undertreatment. It also validates the use of KOOS as a relevant outcome measure for our specific patient demographic, which may differ from global populations in terms of disease presentation or cultural pain perception [6].

Our finding should be interpreted in light of the well-documented phenomenon of structure-symptom discordance in osteoarthritis [11]. While we found a statistically significant correlation, it is crucial to recognize that the relationship between radiographic severity (K-L grade) and functional impairment (KOOS score) is not strictly linear. This variability, where function does not always track radiographic severity, is influenced by factors such as the patient's individual pain threshold, central sensitization, overall activity level, and complex psychosocial factors not visible on a radiograph [12]. Therefore, relying solely on K-L grading, which primarily assesses the tibiofemoral compartment, may not fully capture the multifactorial nature of OA severity.

We acknowledge several key limitations inherent to this study's design and execution. First, the cross-sectional design prevents us from establishing temporality or causality; we can only report associations between K-L grade and KOOS at a single point in time. Second, the cohort is subject to surgical-candidate selection bias, as the exclusive focus on pre-Total Knee Replacement (TKR) patients leads to an over-representation of severe, end-stage OA and limits the generalizability of our findings to community-based or early-stage OA populations. Third, the study relies on single-center data from a tertiary referral hospital, which further constrains external validity. Fourth, there is a potential for measurement error in the Kellgren-Lawrence (K-L) grading due to the lack of formal inter- and intra-rater reliability assessments. Finally, the retrospective nature of data collection meant we were unable to systematically analyze crucial clinical metrics known to affect function, such as BMI, limb alignment, or objective gait and strength metrics, which may represent unmeasured confounding factors. Future research should address these limitations using prospective, multicenter designs with a broader range of clinical outcomes.

A crucial additional limitation is the scope and definition of our cohort. By including only patients admitted for primary Total Knee Replacement (TKR), the sample inherently over-represents the severe end of the knee OA spectrum (i.e., higher Kellgren-Lawrence grades). Therefore, the findings primarily reflect the structure-function relationship in advanced-stage OA in the Malaysian population and should not be generalized to community-based or early-stage OA patients.

The external validity of our findings is constrained by several factors. First, as noted in the limitations, the use of pre-TKR patients means our findings are strictly applicable only to those with severe, end-stage knee OA in a surgical setting, and should not be generalized to community-dwelling or non-operative OA populations. Second, the use of convenience sampling in a single tertiary referral centre in Malaysia further limits generalizability, as this may not fully capture the diversity of the Malaysian OA population, particularly those managed in primary care or private settings. Finally, while the correlation between KOOS and K-L grading is a global phenomenon, the absolute KOOS scores and the degree of correlation may differ in non-Malaysian settings due to variations in healthcare access, cultural perceptions of pain [6], and differences in anthropometric factors not collected in this study.

Conclusion

The study found a significant, positive association between the KOOS and the KL grading of participants in this advanced-stage OA cohort. This finding is supportive of clinical decision-making: while higher KL grades are generally associated with worse function, the KOOS score provides crucial patient-reported data necessary for a comprehensive assessment. Therefore, the combination of a high KL grade and a high KOOS score should be used as adjunctive evidence to guide, rather than deterministically rule, the optimal timing for Total Knee Replacement (TKR).

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