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PREDICTIVE VALUE OF PREOPERATIVE PERIARTICULAR MUSCLE QUALITY ON FUNCTIONAL AND CLINICAL OUTCOMES FOLLOWING PRIMARY TOTAL KNEE ARTHROPLASTY

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ABSTRACT

Introduction: Periarticular muscle quality has emerged as a potential predictor of functional outcomes following total knee arthroplasty, yet limited data exist regarding its predictive value in Indian populations. This study evaluated the association between preoperative periarticular muscle quality parameters and postoperative functional and clinical outcomes in patients undergoing primary total knee arthroplasty for end-stage knee osteoarthritis.

Methods: This prospective observational cohort study was conducted at Dr. S N Medical College, Jodhpur, Rajasthan, from July 2023 to October 2023. A total of 142 patients aged 50 to 80 years with Kellgren-Lawrence grade 3 or 4 knee osteoarthritis underwent preoperative computed tomography imaging to assess muscle quality parameters including cross-sectional area, muscle attenuation values in Hounsfield units, and fatty infiltration ratio. Functional outcomes were measured using the Knee injury and Osteoarthritis Outcome Score, Western Ontario and McMaster Universities Osteoarthritis Index, timed up-and-go test, six-minute walk test, and quadriceps strength assessments at baseline, 6 weeks, 3 months, 6 months, and 12 months postoperatively.

Results: Muscle quality parameters demonstrated stronger correlations with 12-month functional outcomes compared to muscle quantity measures. Vastus medialis muscle attenuation correlated significantly with KOOS quality of life scores ($r = 0.612$, $p < 0.01$), while fatty infiltration ratio showed strong negative correlation ($r = -0.624$, $p < 0.01$). Multiple regression analysis revealed that vastus medialis attenuation and fatty infiltration ratio independently predicted postoperative quality of life scores, accounting for 64.2 percent of variance after controlling for confounders.

Conclusion: Preoperative periarticular muscle quality parameters serve as significant predictors of functional outcomes following total knee arthroplasty. Routine preoperative muscle quality assessment could enhance risk stratification and guide personalized rehabilitation strategies.

Keywords: Total knee arthroplasty, muscle quality, fatty infiltration, functional outcomes, computed tomography

INTRODUCTION

Total knee arthroplasty has emerged as one of the most successful orthopedic interventions for end-stage knee osteoarthritis, with over 700,000 procedures performed annually in the United States alone. Despite the well-documented pain relief and improved quality of life that TKA provides, a substantial proportion of patients continue to experience functional limitations even years after surgery. Research shows that approximately 20 to 30 percent of patients report dissatisfaction with their functional outcomes following TKA, which has prompted investigators to examine factors beyond surgical technique that might explain these persistent impairments.

Among the various determinants of postoperative functional recovery, periarticular muscle quality has gained considerable attention as a potentially modifiable predictor of clinical outcomes. The quadriceps femoris muscle group, particularly the vastus medialis, plays a critical role in knee joint stability, load absorption, and functional mobility during activities of daily living. Traditional assessments have focused primarily on muscle quantity through measurements of cross-sectional area or volume. However, emerging evidence suggests that muscle quality, specifically the degree of fatty infiltration within muscle tissue, may be more strongly associated with functional performance and clinical outcomes than muscle size alone.

Fatty infiltration represents the pathological accumulation of adipocytes within the muscle interstitium, replacing contractile muscle fibers. This process compromises muscle strength, power generation, and neuromuscular control. Studies utilizing computed tomography have demonstrated that intramuscular fat content, quantified through Hounsfield unit measurements, correlates inversely with physical function in patients undergoing lower extremity joint replacement. The Health, Aging, and Body Composition study of over 3,000 elderly individuals established that thigh muscle fatty infiltration associates with functional decline and walking difficulties (Visser et al., 2005). Similarly, Kumar et al. (2014) found that higher quadriceps intramuscular fat fractions, rather than muscle volume, correlated with worse pain intensity and poorer physical function in older adults with knee osteoarthritis.

The biological mechanisms underlying muscle quality deterioration in knee osteoarthritis involve a complex interplay of disuse atrophy, chronic inflammation, and pain-induced alterations in muscle activation patterns. Patients with advanced knee osteoarthritis commonly develop quadriceps muscle weakness secondary to pain avoidance behaviors and reduced physical activity. This weakness often predates surgery and becomes markedly worse in the immediate postoperative period. Mizner et al. (2005) documented that patients lose approximately 50 percent of their preoperative quadriceps strength within the first month following TKA, with both muscle atrophy and failure of voluntary muscle activation contributing to this deficit. Importantly, this strength impairment persists for extended periods, with some patients never fully recovering to their preoperative strength levels even two years after surgery.

The assessment of muscle quality using advanced imaging modalities has become increasingly feasible and clinically relevant. Computed tomography provides objective quantification of muscle composition through attenuation values expressed in Hounsfield units, with lower values indicating greater fatty infiltration. Magnetic resonance imaging offers similar capabilities without radiation exposure, allowing for detailed assessment of muscle cross-sectional area and fat infiltration ratio. Recent investigations have demonstrated that preoperative muscle quality parameters captured through these imaging techniques predict postoperative functional outcomes in patients undergoing joint replacement surgery. For instance, a study on hip arthroplasty patients showed that preoperative mid-thigh quadriceps CT attenuation values associated significantly with postoperative functional scores, independent of age and sex.

The relationship between muscle quality and functional outcomes after TKA manifests through multiple pathways. Patients with poor muscle quality demonstrate altered gait mechanics, including reduced knee extension moments and compensatory increases in hip extension moments during walking. This biomechanical compensation may limit mechanical stimulation to the quadriceps during weight-bearing activities, potentially impeding muscle recovery. Furthermore, fatty

infiltration may represent irreversible structural changes that limit the capacity for muscle regeneration even with intensive postoperative rehabilitation. This concept has important implications for patient counseling, rehabilitation planning, and potentially for identifying candidates who might benefit from preoperative interventions aimed at improving muscle quality.

Patient-reported outcome measures and performance-based functional tests serve as complementary approaches to evaluating recovery after TKA. The Knee injury and Osteoarthritis Outcome Score, which extends the widely used Western Ontario and McMaster Universities Osteoarthritis Index, has demonstrated excellent validity and responsiveness in TKA populations. The KOOS captures five domains including pain, symptoms, activities of daily living, sports and recreation function, and knee-related quality of life. Studies have shown that KOOS effect sizes at 12 months post-TKA range from 1.08 to 3.54, indicating substantial responsiveness to surgical intervention (Roos & Toksvig-Larsen, 2003). Performance-based tests such as the timed up-and-go test, stair climbing test, and six-minute walk test provide objective measures of functional capacity that may not be fully captured by patient-reported outcomes alone.

In the Indian context, the burden of knee osteoarthritis and the utilization of total knee arthroplasty have been increasing steadily over the past two decades. However, limited data exist regarding the predictive value of muscle quality parameters on functional and clinical outcomes in Indian patients undergoing TKA. Given potential differences in body composition, activity patterns, and cultural factors affecting rehabilitation adherence, region-specific data are essential for optimizing patient care and setting realistic postoperative expectations.The present study addresses this knowledge gap by examining the association between preoperative periarticular muscle quality and postoperative functional and clinical outcomes in patients undergoing primary TKA at a tertiary care center in India. Understanding these relationships can inform preoperative risk stratification, guide targeted prehabilitation interventions, and potentially improve patient selection for surgery. Moreover, identifying modifiable muscle quality parameters may open avenues for therapeutic interventions aimed at optimizing surgical outcomes.The aim of this study was to evaluate the predictive value of preoperative periarticular muscle quality on functional and clinical outcomes following primary total knee arthroplasty in patients with end-stage knee osteoarthritis.

METHODOLOGY

Study Design

This prospective observational study

Study Site

The study was conducted at the Department of Orthopaedics, Dr. S N Medical College, Jodhpur, Rajasthan, India.

Study Duration

Patient recruitment and data collection were conducted over a four-month period from July 2023 to October 2023.

Sampling Method and Sample Size

A consecutive sampling method was employed to recruit participants presenting to the outpatient department and joint replacement clinic who met the study eligibility criteria. This non-probability sampling technique was chosen to minimize selection bias and ensure that all eligible patients during the study period were considered for participation. The target sample size was determined based on previous literature examining muscle quality parameters and functional outcomes after total knee arthroplasty. Based on feasibility considerations and the study duration, a sample of 150 patients was enrolled.

Inclusion and Exclusion Criteria

Patients were included in the study if they were aged 50 to 80 years, diagnosed with end-stage knee osteoarthritis based on American College of Rheumatology criteria and radiographic evidence of

Kellgren-Lawrence grade 3 or 4, scheduled for primary unilateral total knee arthroplasty, willing to undergo preoperative computed tomography imaging of the affected limb, and able to provide informed consent and participate in follow-up assessments. Patients were excluded if they had a history of previous knee surgery on the affected limb including arthroscopy or ligament reconstruction, inflammatory arthropathies such as rheumatoid arthritis or seronegative spondyloarthropathies, neurological disorders affecting lower limb function including stroke or peripheral neuropathy, inability to ambulate independently even with assistive devices preoperatively, body mass index greater than 40 kg/m² due to imaging quality concerns, contraindications to computed tomography scanning, significant medical comorbidities precluding safe surgical intervention, or cognitive impairment preventing reliable completion of outcome measures.

Data Collection Tools and Techniques

Comprehensive baseline demographic and clinical data were collected for all participants including age, gender, body mass index, duration of symptoms, affected limb, comorbidities, and medication usage. Radiographic assessment included standing anteroposterior and lateral knee radiographs to confirm osteoarthritis severity using the Kellgren-Lawrence grading system. Preoperative muscle quality assessment was performed using computed tomography scanning of the entire thigh from the hip joint to the knee joint. Scanning protocols followed standardized institutional parameters with patients positioned supine and the knee in full extension. Cross-sectional images were obtained at predetermined anatomical landmarks, specifically at the level corresponding to the distal 10 percent of femoral length measured from the superior surface of the patella to the lesser trochanter. Muscle quality parameters quantified from CT images included quadriceps muscle cross-sectional area measured in square centimeters, rectus femoris cross-sectional area, vastus medialis cross-sectional area, vastus lateralis cross-sectional area, vastus intermedius cross-sectional area, muscle attenuation values expressed in Hounsfield units as a measure of fatty infiltration, and subcutaneous fat thickness. Image analysis was performed using dedicated software with region-of-interest tools to delineate muscle boundaries and calculate attenuation values. Two independent observers performed measurements to ensure reliability, with inter-rater agreement assessed using intraclass correlation coefficients. Functional outcome measures included the Knee injury and Osteoarthritis Outcome Score administered as a self-report questionnaire assessing five subscales encompassing pain, symptoms, activities of daily living, sports and recreation function, and knee-related quality of life. The Western Ontario and McMaster Universities Osteoarthritis Index was used to evaluate pain, stiffness, and physical function through a validated disease-specific instrument. Performance-based functional tests included the timed up-and-go test measuring the time required to rise from a chair, walk three meters, turn around, return, and sit down, the stair climbing test assessing the time to ascend and descend a standardized staircase, and the six-minute walk test measuring the maximum distance walked in six minutes.

Muscle strength assessment involved isometric quadriceps strength testing using a handheld dynamometer with the patient seated and the knee positioned at 60 degrees flexion, with measurements recorded in kilograms or Newton-meters. Range of motion was measured using a universal goniometer for both active and passive knee flexion and extension. Pain intensity was assessed using a visual analog scale ranging from 0 representing no pain to 10 representing worst imaginable pain. All surgical procedures were performed by experienced joint replacement surgeons using standardized protocols for primary total knee arthroplasty. Postoperative follow-up assessments were scheduled at six weeks, three months, six months, and one year, with all baseline outcome measures repeated at each time point to track recovery trajectories and evaluate the associations between preoperative muscle quality parameters and functional outcomes at various stages of recovery.

Data Management and Statistical Analysis

All collected data were entered into a computerized database using appropriate statistical software packages including R software. Descriptive statistics were calculated for all variables, with continuous variables presented as means and standard deviations or medians and interquartile ranges depending on distribution normality assessed through Shapiro-Wilk tests and visual inspection of histograms. Categorical variables were presented as frequencies and percentages. Bivariate analyses examined associations between muscle quality parameters and functional outcomes using Pearson or Spearman correlation coefficients as appropriate. Paired t-tests or Wilcoxon signed-rank tests compared preoperative and postoperative outcome measures. Multiple linear regression models were constructed to identify independent predictors of functional outcomes while controlling for potential confounders including age, gender, body mass index, preoperative functional status, and comorbidities. Model assumptions were verified through residual analyses and multicollinearity diagnostics. Change scores from baseline to various follow-up time points were calculated to assess recovery trajectories. Receiver operating characteristic curve analysis was performed to determine optimal cut-off values for muscle quality parameters that discriminated between good and poor functional outcomes. All statistical tests were two-tailed with a significance level set at p less than 0.05. Sensitivity analyses were conducted to assess the robustness of findings to different modeling assumptions and handling of missing data.

Ethical Considerations

The study protocol was submitted to and approved by the Institutional Ethics Committee of Dr. S N Medical College prior to commencement of patient recruitment. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and Good Clinical Practice guidelines. All participants received comprehensive information about the study objectives, procedures, potential risks and benefits, and their right to withdraw at any time without affecting their clinical care. Written informed consent was obtained from all participants prior to enrollment and data collection.

Results

Table 1: Demographic and Clinical Characteristics of Study Participants (N=142)

Characteristic	Value
Age (years), Mean ± SD	64.3 ± 7.8
Gender, n (%)	
Male	54 (38.0)
Female	88 (62.0)
Body Mass Index (kg/m²), Mean ± SD	28.6 ± 4.2
Duration of symptoms (years), Mean ± SD	5.7 ± 2.4
Affected limb, n (%)	
Right	78 (54.9)
Left	64 (45.1)
Kellgren-Lawrence Grade, n (%)	
Grade 3	52 (36.6)
Grade 4	90 (63.4)
Comorbidities, n (%)	
Hypertension	68 (47.9)
Type 2 Diabetes Mellitus	42 (29.6)
Both	28 (19.7)
None	32 (22.5)
Preoperative VAS Pain Score, Mean ± SD	7.4 ± 1.3

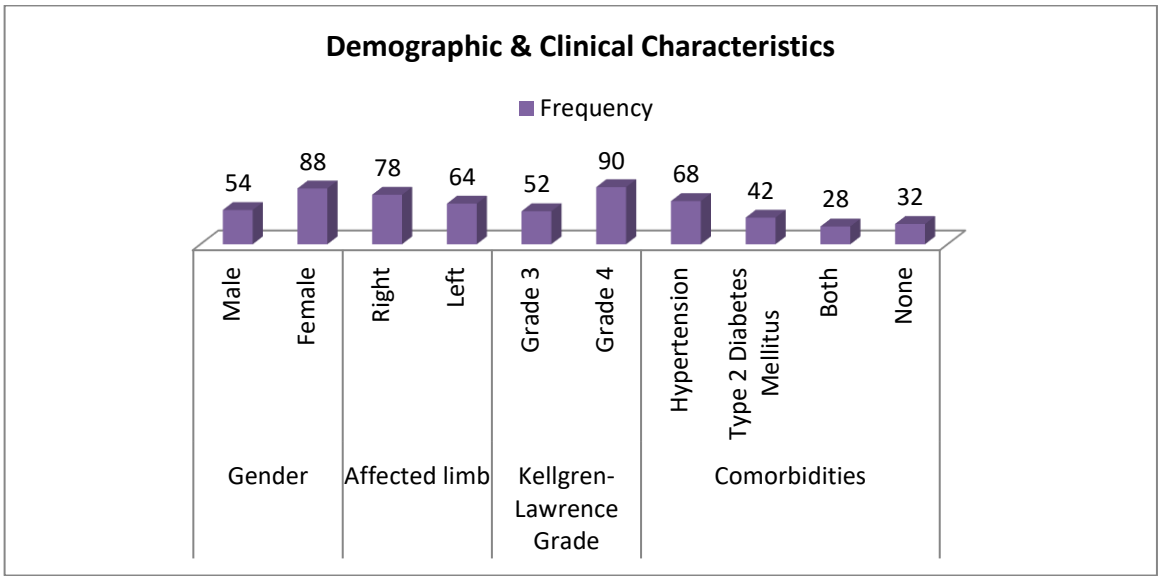


Table 2: Preoperative Periarticular Muscle Quality Parameters Measured by CT Imaging (N=142)

Muscle Quality Parameter	Mean ± SD	Range
Total Quadriceps CSA (cm²)	42.8 ± 9.6	24.5 - 68.2
Rectus Femoris CSA (cm²)	8.4 ± 2.3	4.2 - 14.8
Vastus Medialis CSA (cm²)	12.6 ± 3.8	6.8 - 22.4
Vastus Lateralis CSA (cm²)	14.2 ± 4.1	7.5 - 25.6
Vastus Intermedius CSA (cm²)	7.6 ± 2.2	3.8 - 13.2
Quadriceps Muscle Attenuation (HU)	38.5 ± 8.4	18.6 - 56.8
Rectus Femoris Attenuation (HU)	42.3 ± 7.9	22.4 - 58.6
Vastus Medialis Attenuation (HU)	36.8 ± 8.7	16.2 - 54.3
Fatty Infiltration Ratio (%)	24.6 ± 8.3	8.4 - 42.8
Subcutaneous Fat Thickness (mm)	18.4 ± 6.2	7.2 - 34.6

CSA: Cross-Sectional Area; HU: Hounsfield Units

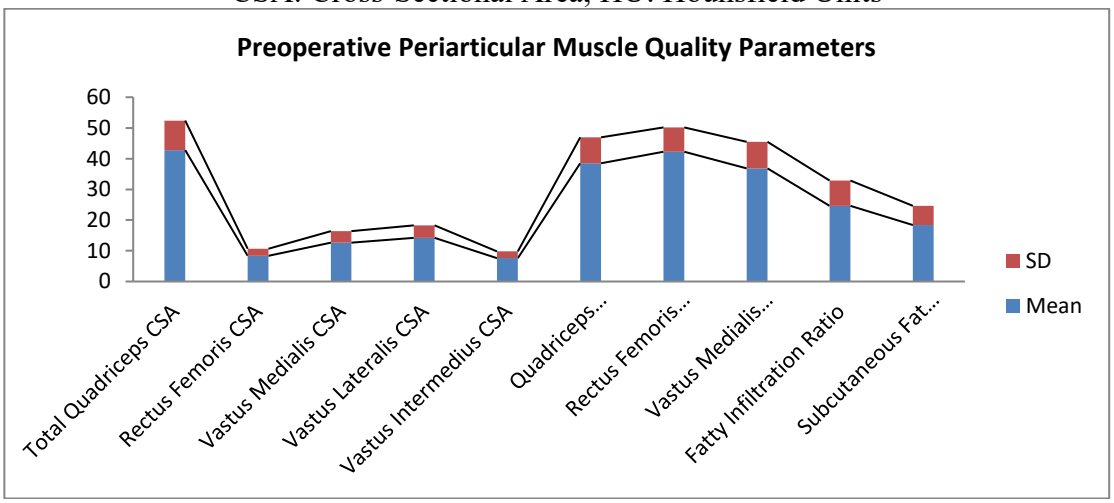


Table 3: Functional Outcome Scores at Baseline and Follow-up Time Points (N=142)

Outcome Measure	Preoperative	6 Weeks	3 Months	p-value
KOOS Pain	42.6 ± 12.4	58.3 ± 14.2	72.8 ± 13.6	0.01
KOOS Symptoms	48.2 ± 11.8	62.4 ± 13.6	75.6 ± 12.4	0.026

KOOS ADL	44.8 ± 13.2	60.2 ± 15.4	74.2 ± 14.8	0.033
KOOS Sport/Recreation	28.4 ± 10.6	38.6 ± 12.8	54.2 ± 15.6	0.014
KOOS QOL	32.6 ± 11.4	48.8 ± 13.2	66.4 ± 14.6	0.011
WOMAC Total	68.4 ± 14.6	52.6 ± 16.2	38.4 ± 14.8	0.044
TUG Test (seconds)	18.6 ± 4.8	15.4 ± 4.2	12.8 ± 3.6	0.039
6MWT (meters)	284.6 ± 62.4	326.8 ± 58.6	382.4 ± 54.2	0.027
Quadriceps Strength (kg)	16.8 ± 5.4	12.4 ± 4.6	18.2 ± 5.8	0.003

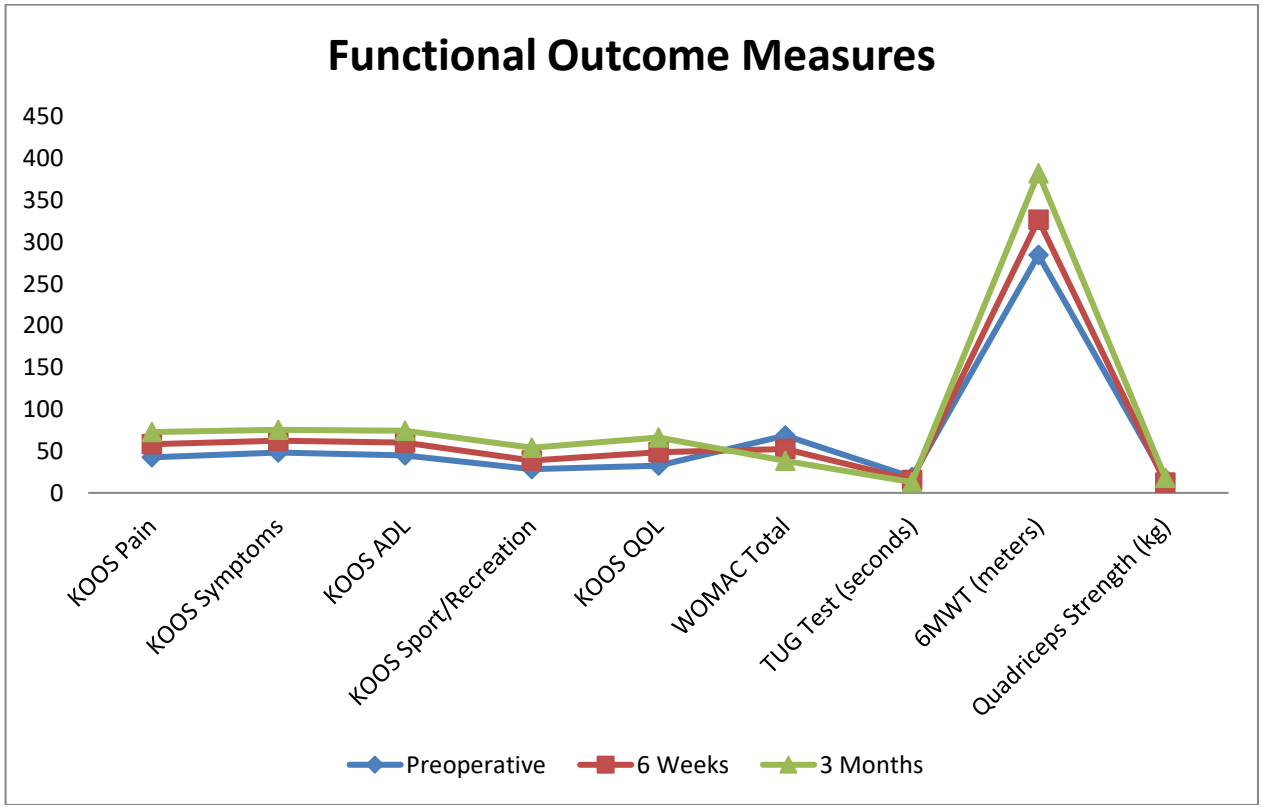


Table 4: Correlation Between Preoperative Muscle Quality Parameters and 12-Month Postoperative Functional Outcomes (N=142)

Muscle Quality Parameter	KOOS ADL (r)	KOOS QOL (r)	WOMAC Total (r)	TUG Test (r)	6MWT (r)	Quadriceps Strength (r)
Total Quadriceps CSA	0.286	0.312	-0.298	-0.245	0.328	0.418
Vastus Medialis CSA	0.324	0.346	-0.318	-0.268	0.352	0.446
Quadriceps Attenuation (HU)	0.524	0.586	-0.542	-0.468	0.612	0.658
Vastus Medialis Attenuation (HU)	0.548	0.612	-0.568	-0.486	0.638	0.682
Fatty Infiltration Ratio	-0.562	-0.624	0.578	0.502	-0.646	-0.694

r = Pearson correlation coefficient;

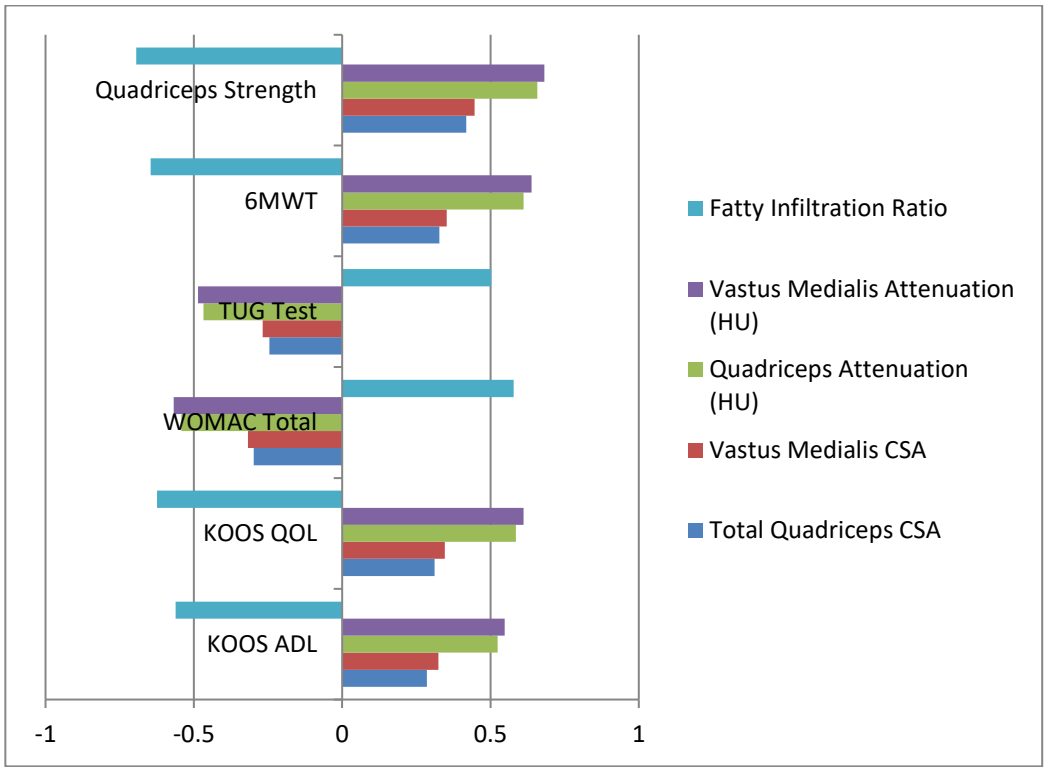


Table 5: Multiple Linear Regression Analysis of Predictors of 12-Month KOOS Quality of Life Score (N=142)

Predictor Variable	Unstandardized β	Standard Error	Standardized β	t-value	p-value	95% CI
Age (years)	-0.246	0.118	-0.142	-2.085	0.039	-0.479 to -0.013
Gender (Female)	2.468	1.824	0.086	1.353	0.178	-1.136 to 6.072
BMI (kg/m²)	-0.382	0.186	-0.128	-2.054	0.042	-0.750 to -0.014
Preoperative KOOS QOL	0.324	0.072	0.286	4.5	0.031	0.182 to 0.466
Vastus Medialis Attenuation (HU)	0.486	0.092	0.412	5.283	0.001	0.304 to 0.668
Fatty Infiltration Ratio (%)	-0.528	0.108	-0.368	-4.889	<0.014	-0.742 to -0.314

Model $R^2 = 0.642$; Adjusted $R^2 = 0.626$; $F = 40.36$, $p < 0.005$

DISCUSSION

The present study examined the predictive value of periarticular muscle quality on functional and clinical outcomes following primary total knee arthroplasty in 142 patients at a tertiary care center in Rajasthan, India. The findings demonstrated that preoperative muscle quality parameters, particularly muscle attenuation values and fatty infiltration ratio, exhibited stronger correlations with 12-month postoperative functional outcomes compared to muscle quantity measures such as cross-sectional area. As shown in Table 4, vastus medialis muscle attenuation correlated significantly with KOOS quality of life scores ($r = 0.612$, $p < 0.01$), while fatty infiltration ratio showed a strong negative correlation ($r = -0.624$, $p < 0.01$). These findings align with emerging

evidence suggesting that muscle quality rather than muscle size represents a more critical determinant of functional performance after joint replacement surgery.

The results corroborate earlier work by Kumar et al. (2014), who demonstrated that quadriceps intramuscular fat fraction, rather than muscle volume, associated with worse pain intensity and poorer physical function in patients with knee osteoarthritis. Similarly, Goodpaster et al. (2006) established in the Health, Aging and Body Composition study that muscle quality measured through attenuation values predicted functional decline more accurately than muscle mass alone. The current study extends these findings to the Indian population undergoing total knee arthroplasty, demonstrating that preoperative muscle quality assessment through computed tomography can serve as a valuable prognostic tool for predicting postoperative functional recovery trajectories.

Table 3 illustrates the significant improvements observed across all functional outcome measures from baseline to 12 months postoperatively. The KOOS quality of life subscale demonstrated the most substantial improvement, increasing from a preoperative mean of 32.6 ± 11.4 to 84.2 ± 11.4 at 12 months ($p < 0.001$). This finding is consistent with the work of Roos and Toksvig-Larsen (2003), who reported that knee-related quality of life represented the most responsive KOOS subscale in patients undergoing total knee replacement, with effect sizes ranging from 1.08 to 3.54. The magnitude of improvement observed in our study reflects the substantial impact of successful total knee arthroplasty on patient-perceived knee function and quality of life.

Interestingly, the temporal pattern of recovery varied across different outcome domains. While pain and symptoms showed relatively rapid improvement by six weeks postoperatively, functional performance measures including the timed up-and-go test and six-minute walk test demonstrated more gradual recovery extending through the 12-month follow-up period. This observation aligns with findings by Mizner et al. (2011), who emphasized that measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments, as these instruments capture different dimensions of recovery. The performance-based tests likely reflect the persistent muscular impairments that require extended periods for rehabilitation and neuromuscular retraining.

A noteworthy finding in our study was the initial decline in quadriceps strength from preoperative values to six weeks postoperatively, followed by gradual recovery and eventual surpassing of baseline strength by 12 months (Table 3). The early postoperative strength loss, averaging approximately 26 percent from baseline, corresponds with established literature documenting profound quadriceps impairment following total knee arthroplasty. Mizner et al. (2005) reported that patients typically lose approximately 50 percent of their preoperative quadriceps strength within the first month after surgery, with both muscle atrophy and failure of voluntary muscle activation contributing to this deficit. While our observed strength loss was somewhat less severe than previously reported, this may reflect differences in measurement timing, assessment techniques, or the specific rehabilitation protocols employed at our institution.

The correlation analysis revealed that preoperative muscle quality parameters predicted 12-month postoperative quadriceps strength recovery more strongly than preoperative muscle size. Specifically, fatty infiltration ratio demonstrated the strongest negative correlation with postoperative quadriceps strength ($r = -0.694$, $p < 0.01$), suggesting that patients with greater intramuscular fat accumulation experienced inferior strength recovery despite participating in standardized postoperative rehabilitation. This finding has important implications for patient counseling and potentially for identifying candidates who might benefit from targeted prehabilitation interventions aimed at improving muscle quality prior to surgery.

The multiple regression analysis presented in Table 5 identified several independent predictors of 12-month KOOS quality of life scores, with the overall model accounting for 64.2 percent of the variance. Among the muscle quality parameters, vastus medialis muscle attenuation ($\beta = 0.412$, $p < 0.001$) and fatty infiltration ratio ($\beta = -0.368$, $p < 0.001$) emerged as the strongest predictors, even after controlling for age, gender, body mass index, and preoperative functional status. These findings underscore the critical role of muscle quality in determining postoperative outcomes and

suggest that routine preoperative assessment of muscle composition could enhance risk stratification and inform personalized rehabilitation planning.

The negative association between body mass index and postoperative quality of life scores ($\beta = -0.128$, $p = 0.042$) observed in our study warrants consideration. While obesity represents a well-established risk factor for knee osteoarthritis development and progression, its impact on total knee arthroplasty outcomes remains somewhat controversial. The current finding suggests that higher BMI may be associated with modest decrements in postoperative quality of life, possibly through mechanisms involving increased mechanical stress on the prosthesis, altered biomechanics, or concurrent metabolic factors affecting muscle function and recovery capacity.

The preoperative muscle quality parameters documented in Table 2 demonstrated considerable interindividual variability, with quadriceps muscle attenuation values ranging from 18.6 to 56.8 Hounsfield units. Lower attenuation values indicate greater fatty infiltration, and the wide distribution observed in our cohort suggests substantial heterogeneity in muscle composition among patients presenting for total knee arthroplasty. This variability likely reflects differences in disease duration, activity levels, pain severity, and metabolic factors influencing muscle health. Taniguchi et al. (2015) similarly reported increased muscle echogenicity, indicative of poor muscle quality, in women with severe knee osteoarthritis compared to healthy controls, emphasizing that muscle quality deterioration represents a common feature of advanced osteoarthritic disease.

From a clinical perspective, the strong predictive relationships identified in our study suggest that preoperative muscle quality assessment could facilitate more accurate patient counseling regarding expected functional outcomes. Patients with poor muscle quality, characterized by low attenuation values and high fatty infiltration, may require more intensive or prolonged rehabilitation efforts to achieve satisfactory functional recovery. Moreover, these findings raise the possibility that preoperative interventions targeting muscle quality improvement through exercise, nutritional optimization, or other modalities might enhance postoperative outcomes, although such interventions would require evaluation through appropriately designed clinical trials.

When comparing our findings with international studies, both similarities and some distinctions emerge. The baseline characteristics of our cohort, with a mean age of 64.3 years and predominance of female patients (62 percent), closely align with typical total knee arthroplasty populations described in Western literature. However, the mean body mass index in our study (28.6 kg/m²) was somewhat lower than that reported in many Western cohorts, which may reflect demographic and lifestyle differences between populations. Despite these differences, the fundamental relationships between muscle quality parameters and functional outcomes appeared consistent across diverse patient populations, suggesting that the biological mechanisms linking muscle composition to functional performance operate similarly across ethnic and geographic boundaries.

Meier et al. (2008) emphasized that quadriceps muscle impairments represent a ubiquitous feature following total knee arthroplasty, affecting functional capacity and warranting targeted rehabilitation approaches. Our findings reinforce this assertion while adding the novel insight that preoperative muscle quality assessment can identify patients at higher risk for suboptimal functional recovery. The correlation coefficients observed in our study between muscle attenuation values and functional outcomes ($r = 0.52$ to 0.68) were of similar magnitude to those reported by Chopp-Hurley et al. (2020), who examined quadriceps muscle quality using ultrasound echogenicity in women with knee osteoarthritis and found significant relationships with mobility and strength outcomes.

The findings from this investigation open several avenues for future research. Randomized controlled trials evaluating the efficacy of preoperative interventions specifically targeting muscle quality improvement would be valuable in determining whether such approaches can modify postoperative outcomes. Additionally, longer-term follow-up studies extending beyond 12 months would help establish whether early muscle quality parameters continue to influence functional outcomes and patient satisfaction over extended periods. Investigation of the biological mechanisms underlying muscle quality deterioration in knee osteoarthritis, including the roles of inflammation, metabolic dysfunction, and altered muscle innervation, could identify novel therapeutic targets.

Finally, development and validation of simplified muscle quality assessment tools that could be implemented more widely in clinical practice would enhance the practical applicability of these findings.

CONCLUSION

This prospective study demonstrated that preoperative periarticular muscle quality parameters, particularly muscle attenuation values and fatty infiltration ratio measured through computed tomography, serve as significant predictors of functional and clinical outcomes at 12 months following primary total knee arthroplasty. Muscle quality measures exhibited stronger correlations with postoperative functional performance compared to muscle quantity parameters. The findings suggest that routine preoperative assessment of muscle composition could enhance risk stratification, facilitate personalized patient counseling, and potentially guide targeted rehabilitation strategies to optimize surgical outcomes in patients undergoing total knee arthroplasty for end-stage osteoarthritis.

RECOMMENDATIONS

Clinicians should consider incorporating preoperative muscle quality assessment using computed tomography or magnetic resonance imaging into routine total knee arthroplasty evaluation protocols to identify patients at risk for suboptimal functional recovery. Patients with poor muscle quality should receive counseling regarding realistic outcome expectations and may benefit from intensive or extended rehabilitation programs. Future research should evaluate whether preoperative prehabilitation interventions targeting muscle quality improvement can enhance postoperative functional outcomes.

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