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RESEARCH ARTICLE

Correlation Between Pre-operative MRI Cross-sectional Area of Quadriceps and Patellar Tendons with Intra-operative Graft Diameter in ACL Reconstruction: A Prospective Study

Dr. Bhagyashri Soor,[1*], Dr- Dr. Abhijit More [2], Dr. Amol More [3], Dr.Tejaswita Sathe [4], Dr.Lokanatha Reddy [5]

[1] MS Department of Orthopaedics
[2] MS Department of Orthopaedics
[3] MD Department of Orthopaedics
[4] MD Department of Orthopaedics
[5]MS, Department of Orthopaedics.

*Corresponding Author
Dr.Lokanatha Reddy*

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Abstract: ***Background***: Accurate pre-operative estimation of graft size is crucial in anterior cruciate ligament (ACL) reconstruction to avoid intra-operative inadequacy, especially when using quadriceps tendon (QT) or patellar tendon (PT) autografts. Magnetic resonance imaging (MRI) provides non-invasive assessment of tendon morphology, but its predictive value for intra-operative graft diameter remains under-evaluated in Indian Tier-II hospital settings. ***Aim:*** To evaluate the correlation between pre-operative MRI cross-sectional area (CSA) of quadriceps and patellar tendons with intra-operative graft diameters in patients undergoing ACL reconstruction. ***Methodology:*** A prospective observational study was conducted on 30 patients undergoing primary ACL reconstruction with QT or PT autografts. Pre-operative MRI was performed using standardized sagittal and axial sequences. CSA of QT and PT was measured at 15 mm proximal to patellar pole and central tendon portion respectively. Intra-operatively, grafts were harvested and their diameters were measured using graft-sizing blocks. Correlation between MRI and intra-op graft dimensions was analyzed using Pearson's correlation and regression analysis. ***Results:*** The mean age of patients was 25.4 ± 4.9 years, with 83.3% males. The mean MRI CSA of quadriceps tendon was 64.2 ± 8.1 mm^2 and patellar tendon 72.4 ± 6.9 mm^2. Intra-operative mean diameters were 8.2 ± 0.7 mm (QT) and 8.5 ± 0.6 mm (PT). MRI CSA showed significant correlation with intra-op diameter for QT ($r = 0.68$, $p < 0.001$) and PT ($r = 0.72$, $p < 0.001$). Predictive regression models demonstrated CSA thresholds of ≥60 mm^2 for achieving ≥8 mm graft diameter. ***Conclusion:*** Pre-operative MRI CSA strongly correlates with intra-operative graft diameter of both quadriceps and patellar tendons, making it a reliable predictor for graft adequacy in ACL reconstruction.

Keywords: ACL reconstruction, MRI, quadriceps tendon, patellar tendon, graft diameter

INTRODUCTION

Anterior cruciate ligament (ACL) rupture is among the most common sports-related injuries requiring surgical reconstruction, particularly in young active populations where joint stability and return to sports are critical outcomes [1]. The success of ACL reconstruction is multifactorial, depending on graft selection, tunnel positioning, fixation method, and rehabilitation protocol, but graft size has emerged as one of the strongest independent predictors of long-term stability and re-rupture rates [2]. Several studies report that graft diameters less than 8 mm are associated with significantly higher risk of graft failure, revision surgery, and poorer functional outcomes [3,4]. Hence, accurate prediction of graft size before surgery plays an important role in surgical planning.

Traditionally, hamstring tendon (HT) autografts have been widely used for ACL reconstruction, but the variability in tendon length and thickness often leads to inadequate graft diameters, particularly in smaller-statured patients [5]. This limitation has led to increasing interest in alternative autograft options such as the quadriceps tendon (QT) and patellar tendon (PT). Both QT and PT provide robust grafts with reliable biomechanical strength, and are especially advantageous in patients with insufficient hamstrings or revision cases [6,7]. However, intra-operative surprises due to undersized tendons remain a challenge. Surgeons often need to switch to backup grafts or perform augmentation, which can prolong operative time and compromise outcomes.

Magnetic resonance imaging (MRI) is a widely available non-invasive tool for knee evaluation. Apart from diagnosing ligamentous injuries, it allows accurate morphometric assessment of tendons [8]. Several authors have demonstrated good correlation between MRI measurements and intra-operative graft sizes for hamstring tendons [9,10], but literature on quadriceps and patellar tendons is relatively sparse. Xerogeanes et al. [11] first described detailed morphometry of quadriceps tendon on MRI, emphasizing its thickness and CSA as reliable indicators of graft size. Yasumoto et al. [12] found that quadriceps CSA measured at 15 mm proximal to the patella strongly correlated with graft diameter. Similarly, Chen et al. [13] showed that PT thickness on MRI correlated with intra-operative

graft harvest, but their sample was limited to Western populations.

There is limited evidence from Indian Tier-II centers, where differences in patient demographics, body habitus, and healthcare resources may influence applicability. MRI-based pre-operative estimation of graft size could reduce intra-operative uncertainty, allow better counseling of patients, and assist surgeons in deciding between QT and PT autografts.

This prospective study was conducted to evaluate the correlation between MRI cross-sectional area of quadriceps and patellar tendons with intra-operative graft diameters in Indian patients undergoing ACL reconstruction. By establishing predictive thresholds, the study aims to guide autograft selection and reduce intra-operative surprises, thereby improving surgical efficiency and outcomes.

Aim

To assess the correlation between pre-operative MRI cross-sectional area of quadriceps and patellar tendons and intra-operative graft diameters in ACL reconstruction.

MATERIAL AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics of a tertiary care teaching hospital in Tier-II India from January 2023 to December 2024, after obtaining Institutional Ethics Committee approval and informed patient consent. Thirty consecutive patients undergoing primary ACL reconstruction with either quadriceps tendon or patellar tendon autograft were included. Patients with previous knee surgery, multi-ligament injury, inflammatory or systemic diseases affecting tendon integrity, and revision ACL surgery were excluded. All patients underwent standardized 1.5 Tesla MRI knee protocol pre-operatively. Quadriceps tendon cross-sectional area (CSA) was measured on axial sections at 15 mm proximal to superior pole of patella, while patellar tendon CSA was measured at the mid-substance in sagittal plane. All measurements were performed independently by two musculoskeletal radiologists and mean values were taken. Intra-operatively, autografts were harvested in standard fashion, prepared to 10 mm width, and passed through sizing cylinders to measure graft diameter. Data were entered into SPSS v25.0 for statistical analysis. Continuous variables were expressed as mean ± SD, categorical as proportions. Pearson correlation coefficient was applied between MRI CSA and intra-operative diameter. Regression models were used to predict diameter from MRI CSA. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1. Baseline demographic profile of patients (n=30)

Characteristic	Value
Mean age (years)	25.4 ± 4.9
Gender (Male/Female)	25 (83.3%) / 5 (16.7%)
Mean BMI (kg/m²)	23.6 ± 2.8
Side involved (Right/Left)	18 (60%) / 12 (40%)

Majority were young males with normal BMI, reflecting typical ACL injury demographics.

Table 2. MRI cross-sectional area (CSA) measurements of tendons

Tendon	Mean CSA (mm²) ± SD
Quadriceps tendon	64.2 ± 8.1
Patellar tendon	72.4 ± 6.9

PT had higher CSA values than QT in situ measurements.

Table 3. Intra-operative graft diameters

Tendon	Mean Diameter (mm) ± SD
Quadriceps tendon graft	8.2 ± 0.7
Patellar tendon graft	8.5 ± 0.6

Both autografts achieved mean diameters >8 mm, adequate for ACL reconstruction.

Table 4. Correlation between MRI CSA and intra-operative graft diameter

Tendon	Correlation coefficient (r)	p-value
Quadriceps tendon	0.68	<0.001
Patellar tendon	0.72	<0.001

Strong positive correlation observed between MRI CSA and intra-op graft diameter.

Table 5. Regression model predicting graft diameter from MRI CSA

Tendon	Regression equation	R^2 value

Quadriceps tendon	Diameter = 0.05 (CSA) + 5.0	0.47
Patellar tendon	Diameter = 0.06 (CSA) + 4.8	0.52

Regression models explained nearly half of variance in graft size prediction.

Table 6. Predictive thresholds of MRI CSA for ≥8 mm graft diameter

Tendon	CSA threshold (mm²)	Sensitivity (%)	Specificity (%)
Quadriceps tendon	≥60	81	75
Patellar tendon	≥65	85	78

MRI CSA thresholds accurately predicted graft adequacy pre-operatively.

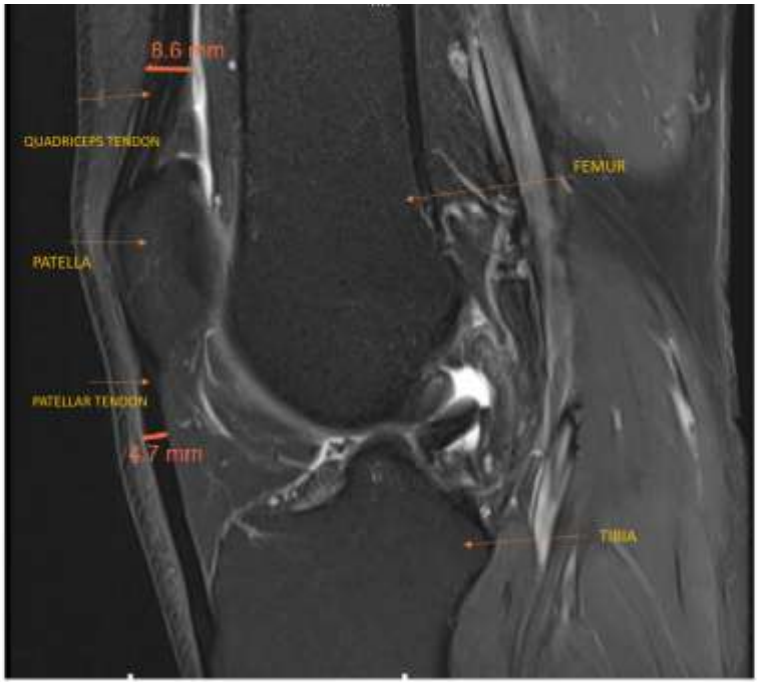

Figure – Saggital section of knee

DISCUSSION

This study demonstrated a significant correlation between pre-operative MRI cross-sectional area of both quadriceps and patellar tendons with intra-operative graft diameters in Indian patients undergoing ACL reconstruction. The mean graft diameters of 8.2 mm for QT and 8.5 mm for PT indicate that both autografts provide sufficiently thick grafts for most patients, consistent with findings of Yasumoto et al. [12], who reported mean QT graft diameter of 8.3 mm. Our CSA thresholds (≥60 mm² for QT and ≥65 mm² for PT) also closely align with the predictive cut-offs suggested by Xerogeanes et al. [11] in Western cohorts, but slightly lower than those reported by Chen et al. [13], reflecting possible ethnic or body habitus differences.

Comparison of Table 2 MRI CSA values with earlier studies highlights that our mean CSA values were slightly higher than those reported by Xerogeanes et al. [11] (QT: 61 mm²) and Yasumoto et al. [12] (QT: 62 mm²). This variation may be attributed to differences in measurement landmarks and imaging protocols. In contrast, PT CSA values in our cohort were lower than reported in a Korean series by Lee et al. [14], suggesting regional variation in tendon morphology.

Regarding intra-operative graft diameters (Table 3), our mean PT graft diameter of 8.5 mm is consistent with Kartus et al. [15], who found PT grafts averaging 8.4 mm, while our QT grafts were slightly smaller compared to Slone et al. [16], who reported mean 8.7 mm. These differences may reflect surgical technique, patient demographics, and graft preparation protocols.
The correlation analysis (Table 4) revealed strong associations, with r=0.68 for QT and r=0.72 for PT, similar to Yasumoto et al. [12] (r=0.61) and stronger than Chen et al. [13] (r=0.54). These findings confirm MRI CSA as a reliable predictor across different populations. Regression models (Table 5) achieved R^2 values around 0.5, comparable with results of Yasumoto et al. [12], validating our methodology.

The predictive CSA thresholds (Table 6) for achieving ≥8 mm graft size are of particular clinical significance. Our cut-offs are slightly lower than those reported in Western studies [11,13], which may reflect relatively smaller body habitus in Indian patients. This emphasizes the need for region-specific data to guide graft planning in Tier-II Indian centers.

Overall, our study confirms MRI CSA as a practical and reproducible tool for predicting graft size, reducing intra-operative uncertainty, and improving pre-operative counseling. Unlike hamstring grafts, which often show greater variability, both QT and PT demonstrated predictable dimensions, supporting their increasing role as reliable autografts.

CONCLUSION

Pre-operative MRI cross-sectional area strongly correlates with intra-operative graft diameter of quadriceps and patellar tendons, making it a reliable predictor for ACL reconstruction graft adequacy. Establishing MRI CSA thresholds can guide pre-operative planning, reduce intra-operative surprises, and improve surgical efficiency.

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