

Evaluating the Relationship Between Posterior Tibial Slope and Meniscal Thickness in Native Knees

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INTRODUCTION: The relationship between increased posterior tibial slope (PTS) and meniscal injury has been well-documented. Still, little is known about the correlation between bony tibial slope and meniscal thickness. In total knee arthroplasty (TKA), PTS plays a critical role in prosthetic alignment, influencing femorotibial translation, ligament tension, and the flexion gap. While kinematic alignment aims to replicate native PTS, doing so may be unnecessary if meniscal thickness increases proportionally with slope, suggesting the functionally relevant slope is meniscal rather than bony. Prior studies have demonstrated discrepancies between bony and meniscal slope, raising questions about the ideal reference point in TKA. This study aims to evaluate whether increased bony PTS correlates with greater meniscal thickness on MRI of native, non-pathological knees, and to assess the implications of these findings for tibial component alignment in TKA.

METHODS: Following IRB approval, 413 patients who underwent lower extremity MRI at a single institution were retrospectively identified. Demographic and radiographic data were extracted from medical records. After excluding 305 patients with pathological knee injuries, 108 patients with native, non-pathological knees were included in the final analysis. Thickness of the medial and lateral meniscus at the anterior horn, posterior horn, and midbody were measured via MRI. PTS was measured on lateral knee radiographs. All measurements were performed using the EPIC digital caliper tool. Linear regression analysis was conducted with PTS as the independent variable and meniscal thickness parameters as dependent variables. Subgroup analyses were performed based on gender, race, height, and BMI.

RESULTS: Posterior tibial slope (PTS) did not show a statistically significant association with any individual meniscal thickness measurement. A trend was noted in the lateral anterior horn, with increased PTS resulting in a smaller meniscus thickness ($p=0.14$, $R^2=0.02$). Subgroup analyses revealed patient's taller than (>69 inches) demonstrated a significant positive relationship between PTS and meniscus thickness across the different measurements ($\beta=+0.21$, $p=0.001$). Similarly, males showed a statistically positive relationship when compared to females ($\beta=+0.057$, $p=0.029$). Despite Black/African American patients on average having a large PTS compared to White and patients who identified as Other (7.50° vs 7.13° , 6.99° , respectively), there was a trend of Black/African American patients having a negative relationship between PTS and meniscus thickness ($\beta= -0.12$, $p=0.068$). There was no difference regarding PTS and meniscal relationship when comparing different BMI groups.

DISCUSSION: This study investigated the relationship between posterior tibial slope and meniscal thickness in native, non pathological knees, finding no significant overall correlation. Subgroup analyses showed statistically significant positive correlation across all meniscal thickness in male patients ($p=0.029$) and taller patients ($p=0.001$), while a negative trend was demonstrated in Black/African American patients ($p=0.068$). Our study finding clinically relevant subgroup trends, despite a lack of overall correlation between increasing PTS and meniscal thickness, supports the idea that functionally relevant slopes need to be determined by patient-specific meniscal and anatomical features rather than bony geometry, holding implications in tibial component alignment in TKA utilizing kinematic alignment principles.

CLINICAL RELEVANCE: In Total Knee Arthroplasty (TKA), this study found no universal relationship between posterior tibial slope (PTS) and meniscal thickness but identified significant subgroup differences in patient demographics of height, sex, and race. These results suggest that tibial component alignment in TKA should be personalized to individual patient anatomic and meniscal features in addition to bony slope.

IMAGES AND TABLES:

Figure 1. Scatter plots demonstrating the relationship between posterior tibial slope and meniscal thickness at each meniscal region, stratified by race (White, Black/African American, Other)

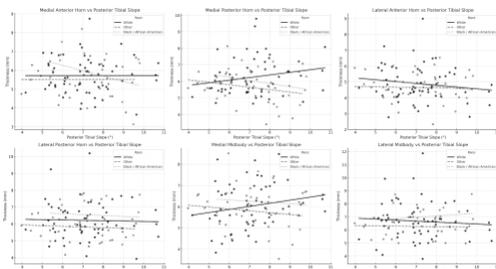


Figure 2. Scatter plots demonstrating the relationship between posterior tibial slope and meniscal thickness at each meniscal region, stratified by height group (<63 in, 63-69 in, >69 in)

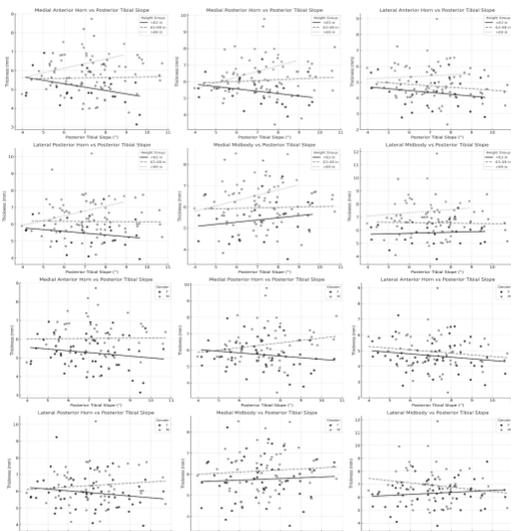


Figure 3. Scatter plot demonstrating the relationship between posterior tibial slope and meniscal thickness at each meniscal region, stratified by sex (male vs female)