Region-Specific Changes in Femoral and Tibial Cartilage Thickness in Individuals with Lateral Discoid Meniscus: A Large-Scale Analysis of 2,796 Knee MRIs

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INTRODUCTION: Discoid meniscus, primarily in the lateral compartment, is a developmental variant that alters meniscal geometry and load transmission, but its compartment- and subregion–specific impact on articular cartilage thickness in otherwise normal knees remains under characterized. We aimed to quantify how the presence of a lateral discoid meniscus relates to cartilage thickness across predefined subregions of the femoral condyles and tibial plateaus in a large pediatric-to-young adult cohort, and to establish normative references that account for skeletal size, age, and sex. We hypothesized that the presence of a discoid meniscus is associated with thinner cartilage.

METHODS: Following IRB approval, we retrospectively analyzed 2,796 knee MRIs (mean age 14.4 ± 4.7 years; range 2–25; 69% female) acquired between 2000–2023. This included the MRIs from subjects with no documented structural abnormalities or injuries to the knee (n=1,920 69%), which served as controls, and those with lateral discoid meniscus (n=876, 31%). Cartilage surfaces of the medial/lateral femoral condyles and tibial plateaus were segmented using a validated 3D deep learning pipeline (Dice > 0.97), with quality control by trained analysts. To account for knee size, all thickness measures were normalized to bicondylar width. Group differences (discoid vs normal) were tested with general linear models (cohort as fixed effect; covariates: age and sex), and reported as adjusted marginal means.

RESULTS: Discoid meniscus was associated with lateral compartment–predominant alterations in cartilage thickness (Figure 1). Adjusted marginal means (Discoid vs Normal) showed consistent thinning of the lateral femoral condyle—posterior 2.25 vs 2.34 mm (mean difference = −0.09 mm (4%), $p < 0.001$), mid 1.91 vs 1.94 mm (mean difference = −0.03 mm (1%), $p < 0.001$), and anterior 2.13 vs 2.35 mm (mean difference = −0.22 mm, (10%) $p < 0.001$). Lateral tibial cartilage exhibited regionally divergent changes—posterior thickening 2.30 vs 2.24 mm (mean difference = +0.06 mm (2%), $p < 0.001$) and anterior thickening 1.56 vs 1.51 mm (mean difference = +0.05 mm, (3%) $p = 0.001$) contrasted with mid-plateau thinning 2.56 vs 2.69 mm (mean difference = −0.13 mm, (5%) $p < 0.001$). Medial compartments were largely preserved, with only small differences in posterior 2.14 vs 2.23 mm (mean difference = −0.09 mm, (4%) $p < 0.001$) and anterior regions 2.45 vs 2.51 mm (mean difference = −0.06 mm, (2%) $p < 0.01$), and no significant mid-compartment differences after normalization. All effects remained significant after adjustment for age and sex.

DISCUSSION: In the largest MRI cohort to date evaluating discoid meniscus and articular cartilage, lateral femoral cartilage is thinner, whereas lateral tibial cartilage shows subregion-specific hypertrophy and thinning, consistent with altered contact mechanics and load redistribution in discoid morphology. Medial surfaces are minimally affected. These normative, size-adjusted references clarify how discoid anatomy reshapes lateral compartment cartilage development and provide a practical baseline for counseling, surveillance, and treatment planning—particularly in adolescents, when cartilage is most dynamic. Prospective longitudinal work should test whether these subregional thickness patterns presage symptoms or accelerated degeneration and whether they are modifiable by activity, alignment, or surgery.

SIGNIFICANCE: By defining how discoid meniscus alters subregion-specific cartilage thickness in a large, pediatric-to–young-adult cohort, this study establishes normative, size-adjusted references that inform counseling, surveillance, and early intervention strategies to mitigate long-term joint degeneration.

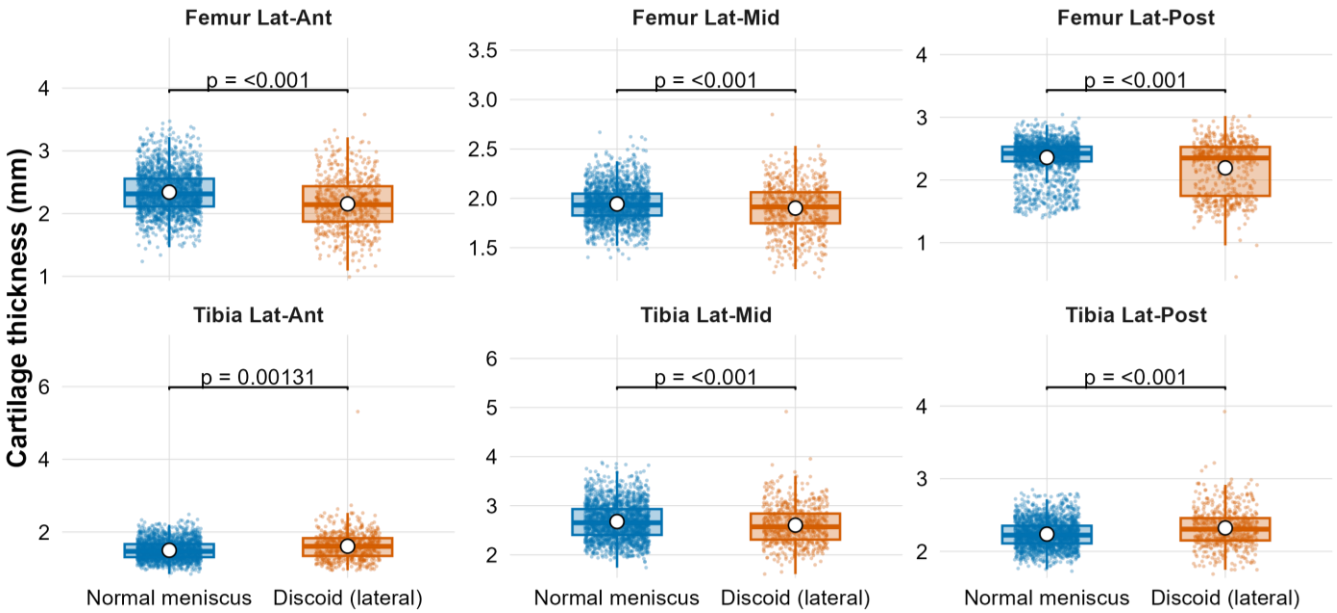

Figure 1: Lateral compartment cartilage thickness by cohort. Raw distributions (jittered points = individual knees) are shown over boxplots (box = IQR, center line = median; white dot = raw mean). P-values above panels come from ANCOVA (thickness ~ cohort + age + sex), with marginal means evaluated at the cohort mean age and sex proportion (≈14.4 y; ≈69% female).