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Association Between Hoffa Fat Pad Morphology And Magnetic Resonance Imaging-Based Posterior Horn Meniscal Grade: A Retrospective Magnetic Resonance Imaging Study

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ABSTRACT

Objective: The objective of the study was to evaluate the association between Hoffa's fat pad morphology and Magnetic resonance imaging (MRI)-based posterior horn meniscal grade and to determine whether this association remained after adjustment for age, sex, and body mass index (BMI).

Materials and Methods: In this retrospective cross-sectional MRI study, 144 adults were intentionally selected using a grade-balanced sampling strategy, with 36 patients assigned to each MRI-based posterior horn meniscal grade (Grades 0–3). Hoffa fat pad thickness and sagittal cross-sectional area (CSA) were measured. Spearman's analysis was used to examine correlations. Group differences were tested by Kruskal–Wallis and Dunn's multiple comparison tests. Ordinal logistic regression was performed to identify factors independently associated with higher MRI-based posterior horn meniscal grade after adjustment for age, sex, and BMI.

Results: Hoffa's fat pad thickness and CSA decreased progressively with increasing meniscal grade. Both parameters showed significant negative correlations with grade severity, stronger for CSA (r=–0.483, p=0.001) than thickness (r=–0.254, p=0.002). Age showed a weak positive correlation with MRI grade (r=0.191, p=0.022); however, this association was not retained after multivariable adjustment. Hoffa's fat pad CSA (odds ratio [OR]=0.985, 95% confidence interval [CI]: 0.980–0.990, p<0.001) and male sex (OR=4.323, 95% CI: 1.921–9.728, p<0.001) were independently associated with higher MRI-based posterior horn meniscal grade. The proportional odds assumption was satisfied. No statistically significant differences in Hoffa fat pad morphology were observed between isolated medial and combined medial+lateral posterior horn involvement.

Conclusion: Hoffa fat pad CSA was inversely associated with MRI-based posterior horn meniscal grade and may represent an imaging feature associated with structural meniscal abnormalities.

Keywords: Degeneration, Infrapatellar fat pad, Knee joint, Magnetic resonance imaging, Menisci

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INTRODUCTION

The menisci play an important role in load transmission, shock absorption, and joint stability in the knee. Degenerative meniscal changes are frequent, especially with increasing age, and are thought to be a major cause of knee pain and osteoarthritis.[1,2] Magnetic resonance imaging (MRI) is considered the gold standard for non-invasive assessment of meniscal lesions, providing information on both morphological and signal changes.[3]

The Infrapatellar fat pad (IFP), also known as Hoffa's fat pad, is an intracapsular and extrasynovial structure in the anterior compartment of the knee. In addition to mechanical function, it is being recognized as a metabolically active tissue in inflammatory and degenerative conditions of the knee joint.[4,5] Hoffa fat pad is known to secrete several cytokines and adipokines that might be involved in cartilage degradation and synovial inflammation.[6]

Recent studies have reported that the Hoffa fat pad is modified structurally (thickness and cross-sectional area [CSA]) in knee joint internal derangements such as osteoarthritis, meniscal disorders, and early degenerative changes, including chondromalacia.[7-9] However, the correlation between Hoffa fat pad morphology and the degree of meniscal degeneration is not fully understood.

Meniscal degeneration is commonly graded using MRI-based classification systems, reflecting progressive structural deterioration. To our knowledge, prior studies have mainly addressed the meniscal tears or osteoarthritis, and limited data exist regarding the association between Hoffa fat pad morphology and MRI-based posterior horn meniscal grades.[10-14] Furthermore, it is still not defined whether demographic or clinical characteristics, including age, sex, and body mass index (BMI), can affect the association.

Therefore, this study aimed to investigate the association between Hoffa fat pad morphology, including sagittal thickness and CSA, and MRI-based posterior horn meniscal grade. In addition, we examined whether these MRI-derived morphological parameters were independently associated with higher MRI-based posterior horn meniscal grades after adjustment for age, sex, and BMI.

MATERIALS AND METHODS

Study Design and Population

This retrospective cross-sectional study was approved by the Gaziantep University Ethics Committee (Decision No: 2026/139; February 18, 2026), and the requirement for informed consent was waived because of the retrospective study design. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Consecutive knee MRI examinations performed between September 01, 2022, and January 30, 2026 were identified from the institutional Picture Archiving and Communication System. A total of 256 consecutive knee MRI examinations were initially reviewed.

Inclusion criteria were as follows: (1) available knee MRI images with good image quality, and (2) patients were adults.

Exclusion criteria were: (1) Previous knee surgery, (2) acute knee injury, (3) inflammatory arthropathy, (4) chondromalacia or significant cartilage degeneration, (5) severe osteoarthritis preventing a reliable meniscal reading, (6) tumor or tumor-similar lesion affecting the knee joint, or (7) inadequate image quality.

After application of the predefined inclusion and exclusion criteria, eligible examinations were categorized according to MRI-based posterior horn meniscal grade (Grades 0–3). To facilitate balanced comparisons across degeneration grades and minimize class imbalance during statistical analyses, a grade-balanced sampling strategy was adopted. Specifically, 36 examinations were randomly selected from each MRI grade whenever more than 36 eligible examinations were available, resulting in a final study cohort of 144 patients (36 patients per grade) (Fig. 1).

Because the study intentionally used a grade-balanced sampling strategy rather than the natural distribution of MRI grades within the source population, the ordinal

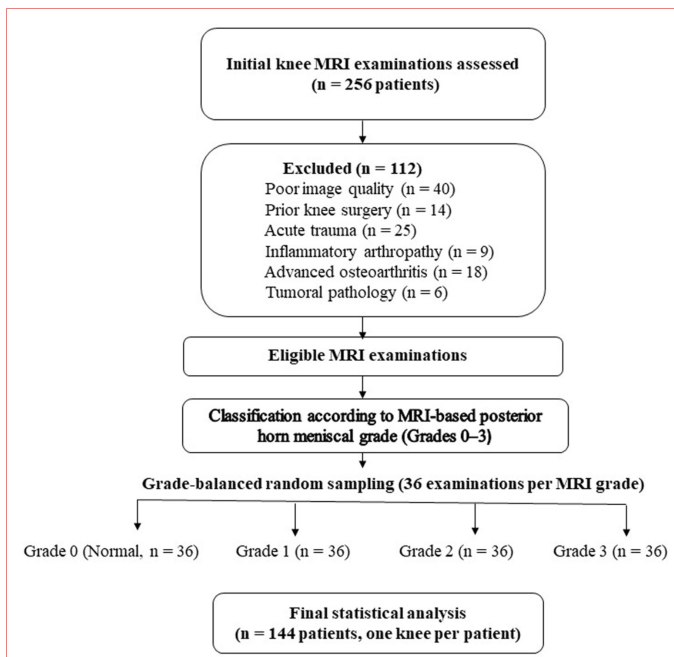

Figure 1. Flowchart of the study design and patient selection process.

logistic regression analyses were designed to evaluate adjusted associations between imaging variables and MRI-based posterior horn meniscal grade within the selected cohort. Therefore, the estimated odds ratios (ORs) should be interpreted as measures of association rather than estimates of population-level risk or predictive performance.

For patients who underwent bilateral knee MRI examinations, only one knee per patient was included to avoid within-subject correlation. When both knees were available, the knee with the higher MRI-based posterior horn meniscal grade was selected for analysis. If both knees demonstrated the same grade, one knee was randomly selected.

MRI Protocol

All MRI examinations were performed using a 1.5-Tesla MRI scanner (Magnetom Aera, Siemens, Germany) with a dedicated knee coil. Patients were positioned supine with the knee in full extension and the patella centered in the coil. No intravenous contrast was administered.

The imaging protocol included the following sequences:

Sagittal proton density (PD) fat-suppressed sequence: Slice thickness 3 mm, interslice gap 0.5 mm, field of view (FOV) 160×160 mm, matrix 320×320, repetition time (TR) 3000 ms, echo time (TE) 30 ms.

Sagittal T1-weighted sequence: Slice thickness 3 mm, FOV 160×160 mm, matrix 320×320, TR 500 ms, TE 10 ms.

Coronal PD fat-suppressed sequence: Slice thickness 3 mm, FOV 160×160 mm, matrix 320×320, TR 2850 ms, TE 30 ms.

Axial PD fat-suppressed sequence: slice thickness 3 mm, FOV 160×160 mm, matrix 320×320, TR 3000 ms, TE 35 ms.

All sequences were acquired with a FOV sufficient to cover the entire knee joint, including the patellofemoral and tibiofemoral compartments. Studies with gross motion artefacts or with poor meniscal or Hoffa fat pad visibility were excluded. For quantitative analysis, measurements were performed on sagittal PD fat-suppressed and sagittal T1-weighted images, while coronal and axial PD fat-suppressed sequences were used for complementary anatomical evaluation and confirmation of associated findings.

Image Analysis

All MRI examinations were independently reviewed by a radiologist with 7 years of musculoskeletal imaging experience, blinded to patients' clinical and demographic information.

Meniscal Evaluation

To avoid confounding effects from varying patterns across different anatomical regions, meniscal degeneration was assessed selectively within the posterior horn of the menisci, where mechanical load transmission is most prominent during joint loading. Degeneration was graded on MRI according to standard imaging criteria:[3,15]

- Grade 0: Normal meniscus structure in the posterior horn
- Grade 1: Focal intrameniscal signal confined to the posterior horn
- Grade 2: Linear intrameniscal signal confined to the posterior horn
- Grade 3: Linear signal extending to at least one articular surface of the posterior horn, consistent with MRI findings of a meniscal tear (Fig. 2).

When different MRI grades were present in the medial and lateral posterior horns, the higher grade was considered the index MRI-based posterior horn meniscal grade for statistical analysis.

Posterior horn involvement was additionally classified as isolated medial involvement or combined medial and lateral

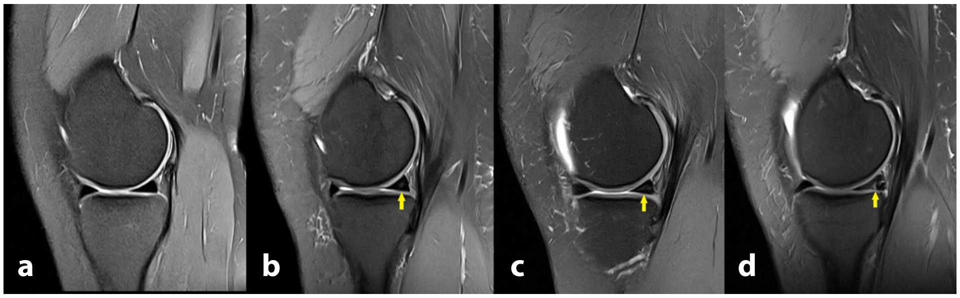

Figure 2. Proton density (PD) weighted sagittal images demonstrating meniscal grading in the posterior horn of the medial meniscus: **(a)** normal, **(b)** grade 1, **(c)** grade 2, and **(d)** grade 3. The relevant findings are indicated by yellow arrows.

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involvement. No patient demonstrated isolated lateral posterior horn abnormalities.

Hoffa Fat Pad Measurements

Hoffa's fat pad was assessed on sagittal MRI images, in accordance with previously published criteria.[9,10,16-18] Measurements included:

Thickness (mm)

The maximal sagittal thickness of the IFP was measured at the level of its greatest anteroposterior dimension, using a line drawn perpendicular to the patellar tendon between the anterior and posterior margins (Fig. 3).

CSA (mm²)

The CSA of the IFP was measured on the sagittal slice demonstrating its largest extent by manually tracing its margins (Fig. 4).

All measurements were performed twice by the same radiologist at a 2-week interval to ensure consistency and assess intraobserver reproducibility, demonstrating good to excellent reliability (intraclass correlation coefficients (ICC)=0.929 for sagittal CSA and 0.947 for sagittal thickness).

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences version 20 software. Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean±standard deviation for normally distributed data and as median (interquartile range) for non-normally distributed data.

Comparisons among MRI grade groups were performed using the Kruskal–Wallis test, followed by Dunn's *post hoc* test with Bonferroni correction. Associations between Hoffa fat pad measurements and MRI-based posterior horn meniscal grade were evaluated using Spearman's rank correlation analysis. Comparisons between isolated medial and combined medial plus lateral posterior horn involvement were performed using the Mann–Whitney U test.

Univariable ordinal logistic regression analyses were first performed to calculate crude ORs for each independent variable. Subsequently, a multivariable ordinal logistic regression model including age, sex, BMI, Hoffa fat pad thickness, and Hoffa fat pad CSA was constructed to identify variables independently associated with higher MRI-based posterior horn meniscal grade. Adjusted ORs with 95% confidence intervals (CIs) were reported.

Because the study used an intentionally grade-balanced sampling strategy, the regression-derived ORs were interpreted as measures of adjusted association within the selected cohort rather than estimates of population-level risk or predictive performance.

Figure 3. T1-weighted sagittal image illustrating measurement of Hoffa's fat pad thickness, indicated by a yellow line.

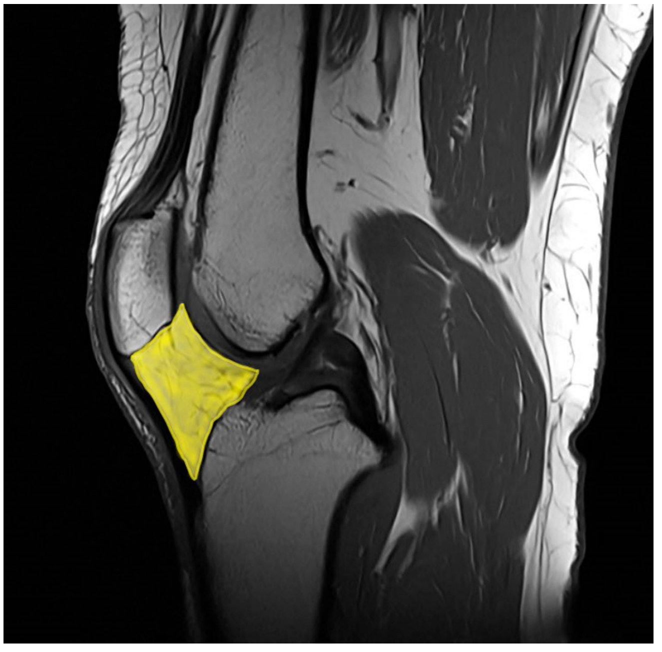

Figure 4. T1-weighted sagittal image illustrating measurement of Hoffa's fat pad cross-sectional area, indicated by a yellow shaded region.

The proportional odds assumption was evaluated using the Test of Parallel Lines. Overall model fit was assessed using Pearson and Deviance goodness-of-fit statistics, together with Cox and Snell, Nagelkerke, and McFadden pseudo-R^2 indices. Multicollinearity among independent variables was assessed using variance inflation factors, and no evidence of problematic multicollinearity was identified.

A two-sided $p<0.05$ was considered statistically significant.

RESULTS

The final study cohort comprised 144 patients (78 women and 66 men) with a mean age of 45.6±13.8 years. According to the study design, 36 patients were included in each MRI-based posterior horn meniscal grade (Grades 0–3). Age did not differ significantly across groups (p=0.064), whereas sex distribution (p=0.974) and BMI (p=0.158) did not differ significantly (Table 1).

Both Hoffa fat pad thickness and sagittal CSA progressively decreased with increasing MRI-based posterior horn meniscal grade (Table 2).

The median Hoffa fat pad thickness was significantly lower in higher MRI grades (p=0.020). Similarly, sagittal CSA demonstrated a progressive reduction across MRI grades and showed a stronger association with MRI-based posterior horn meniscal grade (p=0.001).

Post hoc analyses demonstrated that the most pronounced differences were observed between Grade 0 and Grades 2–3, whereas adjacent MRI grades showed smaller differences.

Spearman correlation analysis demonstrated a significant inverse correlation between Hoffa fat pad thickness and MRI-based posterior horn meniscal grade (r=–0.254, p=0.002). An even stronger inverse correlation was observed for Hoffa fat pad CSA (r=–0.483, p<0.001).

Age demonstrated a weak positive correlation with MRI-based posterior horn meniscal grade (r=0.191, p=0.022) (Table 3). BMI was not significantly correlated with MRI grade (p>0.05).

Univariable ordinal logistic regression analyses demonstrated that lower Hoffa fat pad thickness (OR=0.812, 95% CI: 0.710–0.930, p=0.002), lower Hoffa fat pad CSA (OR=0.989, 95% CI: 0.986–0.993, p<0.001), and increasing age (OR=1.035, 95% CI: 1.004–1.066, p=0.025) were significantly associated with higher MRI-based posterior horn meniscal grade. BMI (OR=1.049, 95% CI: 0.957–1.150, p=0.305) and sex (male vs. female: OR=1.093, 95% CI: 0.609–1.965, p=0.765) were not significantly associated with MRI grade in the univariable analyses (Table 4).

After adjustment for age, sex, BMI, Hoffa fat pad thickness, and Hoffa fat pad CSA, only lower Hoffa fat pad CSA (adjusted OR=0.985, 95% CI: 0.980–0.990, p<0.001) and male sex (adjusted OR=4.323, 95% CI: 1.921–9.728, p<0.001) remained independently associated with higher MRI-based posterior horn meniscal grade, whereas Hoffa fat pad thickness, age, and BMI were no longer independently associated (Table 4).

The multivariable ordinal logistic regression model demonstrated adequate overall fit (Likelihood Ratio χ^2=53.037, p<0.001). Goodness-of-fit statistics indicated satisfactory agreement between observed and expected values (Pearson χ^2=402.496, p=0.767; Deviance χ^2=346.216, p=0.998). The proportional odds assumption was satisfied (Test of Parallel Lines, p=0.754). The model demonstrated moderate explanatory performance (Nagelkerke R^2=0.329, Cox and Snell R^2=0.308, McFadden R^2=0.133).

Among patients with posterior horn abnormalities, 12 patients demonstrated combined medial and lateral posterior horn involvement, whereas the remaining patients showed isolated medial posterior horn involvement.

No significant differences in Hoffa fat pad thickness or CSA were observed between patients with isolated medial posterior horn involvement and those with combined medial and lateral posterior horn involvement (Table 5). However, the combined involvement group was small and consisted only of patients

Table 1. Demographic characteristics according to posterior horn meniscal grade

Characteristic	Grade 0 (*n*=36)	Grade 1 (*n*=36)	Grade 2 (*n*=36)	Grade 3 (*n*=36)	p
Age (years), mean±SD	35.69±8.8	39.61±10.5	41.53±7.8	41.11±11.6	0.064
Sex (Male/Female), *n*	18/18	17/19	16/20	17/19	0.974
BMI (kg/m^2), mean±SD	25.06±2.6	25.05±2.9	26.78±3.4	25.33±3.4	0.136
Side (Right/Left), *n*	13/23	21/15	16/20	18/18	0.285
Meniscus involvement (Medial / Medial+Lateral), *n*	36/0	36/0	32/4	28/8	0.001*

Data are presented as mean±standard deviation for continuous variables and number (*n*) for categorical variables. p-values were calculated using the Kruskal–Wallis test for continuous variables and the Chi-square test for categorical variables. *Post-hoc* comparisons were performed using Dunn's test when appropriate. *p<0.05 considered statistically significant

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Table 2. Hoffa fat pad thickness and cross-sectional area according to meniscal grade

Grade	Thickness (mm), median (IQR)	Cross-sectional area (mm^2), median (IQR)	p*
0	21.75 (20-23)[a]	618.75 (558.5-679.75)[a]	0.020/0.001
1	21.03 (20-22)[a]	561.53 (499.25-624)[b]	
2	20.33 (19-22)[ab]	513.72 (457.5-561)[c]	
3	20.25 (19-21.75)[b]	500.03 (448.25-545.5)[c]	

Values are expressed as median (interquartile range). Overall differences between groups were assessed using the Kruskal–Wallis test. Pairwise comparisons were performed using Dunn's test with Bonferroni correction. Superscript letters indicate statistically significant differences between grades. *p<0.05 considered statistically significant; IQR: Interquartile range

Table 3. Correlation between Hoffa fat pad morphology, age, and meniscal grade

Variable	Spearman r	p
Hoffa thickness versus Meniscal grade	−0.254	0.002
Hoffa cross-sectional area versus Meniscal grade	−0.483	0.001
Age versus meniscal grade	0.191	0.022

Correlations were analyzed using Spearman's rank correlation coefficient. Spearman r indicates the strength and direction of the correlation: Positive r → direct relationship, Negative r → inverse relationship

Table 4. Univariable and multivariable ordinal logistic regression analyses of factors associated with higher MRI-based posterior horn meniscal grade

Variable	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
Hoffa fat pad thickness (mm)	0.812 (0.710–0.930)	0.002	0.948 (0.800–1.123)	0.535
Hoffa cross-sectional area (mm^2)	0.989 (0.986–0.993)	<0.001*	0.985 (0.980–0.990)	<0.001*
Age (years)	1.035 (1.004–1.066)	0.025	1.016 (0.983–1.051)	0.345
Male sex (vs. female)	1.093 (0.609–1.965)	0.765	4.323 (1.921–9.728)	<0.001*
BMI (kg/m^2)	1.049 (0.957–1.150)	0.305	0.998 (0.901–1.105)	0.972

Lower Hoffa fat pad cross-sectional area and male sex were independently associated with higher MRI-based posterior horn meniscal grade after adjustment for age, sex, and BMI. OR: Odds ratio, CI: Confidence interval, BMI: Body mass index. Female was used as the reference category. *p<0.05 was considered statistically significant

Table 5. Hoffa fat pad thickness and cross-sectional area according to the pattern of posterior horn meniscal involvement

Parameter	Medial (*n*=132)	Medial+Lateral (*n*=12)	p
Hoffa thickness (mm)	20.83 (19–22)	20.92(18.5–23.25)	0.875
Hoffa cross-sectional area (mm^2)	552.89 (479–627)	500.33(461.25–537)	0.480

Data are presented as median (interquartile range). Differences between groups were assessed using the Mann–Whitney U test. P<0.05 was considered statistically significant. Owing to the small number of patients with combined medial and lateral involvement (*n*=12), this comparison should be interpreted with caution

with higher MRI-based posterior horn grades. Therefore, these findings should be interpreted with caution, and larger studies are needed to better define the effect of concomitant lateral meniscal involvement on Hoffa fat pad morphology.

DISCUSSION

Our study demonstrated a significant inverse association between Hoffa fat pad morphology and MRI-based posterior horn meniscal grade. Both sagittal thickness and

CSA decreased progressively with increasing MRI-based posterior horn meniscal grade. Among these measurements, CSA showed the strongest association with MRI grade and remained independently associated after adjustment for age, sex, and BMI.

The menisci are essential for load transmission and joint stability, and structural meniscal abnormalities are associated with knee osteoarthritis.[1,2] MRI continues to be the gold standard in meniscal assessment, enabling accurate visualization of intrameniscal signal changes.[3,12] However, a growing body of evidence indicates that knee degeneration is not cartilage and menisci alone, but rather extend also into neighboring soft tissue structures such as the IFP.[4,5]

The IFP is now considered a metabolically active tissue that secretes proinflammatory cytokines and adipokines that may participate in the process of joint degeneration.[5,6,13] Previous studies have mainly investigated the association between Hoffa fat pad morphology and osteoarthritis. For instance, Cai et al.[7] reported an association between fat pad volume and structural knee changes, while Li et al.[10] demonstrated that MRI-based radiomic features of the fat pad could predict osteoarthritis development. Similarly, Ruhdorfer et al.[17] showed that differences in fat pad size and signal characteristics were associated with disease progression.

Contrary to these studies on osteoarthritis, the aim of our study was to investigate the association between Hoffa fat pad morphology and MRI-based posterior horn meniscal grade. Focusing on the posterior horn is clinically paramount because it bears the maximum mechanical stress during weight-bearing flexion, acting as the primary anchor against joint subluxation.[1,2] The results of our study demonstrate that fat pad modifications strongly correlate with the degree of posterior horn meniscal grade. These morphological changes may be observed earlier in the degenerative cascade, prior to the appearance of late-stage osteoarthritis. Importantly, patients with chondromalacia and significant cartilage degeneration were excluded from the study. Therefore, the observed associations are less likely to be driven by concomitant cartilage pathology and may more specifically reflect the relationship between Hoffa fat pad morphology and meniscal grade. This design differs from previous studies investigating osteoarthritis or chondromalacia, in which cartilage abnormalities may have substantially influenced IFP morphology.

Interestingly, we observed a reduction in both thickness and CSA of the fat pad with increasing meniscal grade. While some studies have reported enlargement or increased signal intensity of the fat pad in inflammatory states,[11,19] others have suggested that chronic degeneration may lead to fibrosis, volume loss, or structural remodeling.[17,18] Our findings support the latter hypothesis, indicating that progressive posterior horn meniscal grade may be associated with a reduction in fat pad size, possibly due to chronic mechanical stress or tissue remodeling processes driven by posterior joint compartment breakdown.

Unlike previous studies utilizing complex volumetric 3D segmentation or advanced radiomics analysis of the total IFP volume (e.g., Li et al.,[10] Cai et al.,[7]), our study utilized a single-slice sagittal CSA approach. While volumetric assessments provide a total representation of fat pad mass, they are computationally intensive, require dedicated commercial software, and are difficult to integrate into high-throughput clinical radiology workflows. Our findings suggest that a pragmatic, single-slice sagittal CSA measurement successfully captures the macro-structural remodeling of the IFP associated with intra-articular breakdown. Our findings suggest that a single-slice sagittal CSA measurement captures structural alterations of the Hoffa fat pad associated with MRI-based posterior horn meniscal abnormalities. The excellent intraobserver reproducibility observed in the present study supports the consistency of this measurement approach (ICC=0.929). Nevertheless, interobserver reproducibility was not evaluated, and further validation is required before routine clinical implementation can be recommended.

Of the parameters assessed, fat pad CSA was more strongly correlated with posterior horn meniscal grade than thickness. This result is in agreement with methodological studies demonstrating that CSA- or volume-based measures better represent global structural changes and are less affected by local anatomical variation.[16,17] Crucially, our updated multivariate analysis revealed that male sex was also independently associated with higher posterior horn meniscal grades (OR=4.323, $p<0.001$). This structural divergence aligned with epidemiological data highlighting sex-specific variations in knee biomechanics, joint loading, and the baseline distribution of meniscal volume, suggesting that sex represents an essential covariate in structural joint remodeling. In the multivariable analysis, lower Hoffa fat pad CSA and male sex were independently associated with higher MRI-based posterior horn meniscal grade. Because sex distribution did not differ significantly among MRI grade groups in the univariable analysis, this finding should be interpreted with caution. It may reflect the effect of adjustment for other covariates rather than an isolated biological effect of sex. Further validation in independent cohorts is warranted.

In contrast, age and BMI were not independently associated with degeneration severity in the multivariate model. Previous studies have suggested that these factors may influence Hoffa fat pad morphology and knee osteoarthritis development,[8,13] our findings indicate that Hoffa fat pad shape may be more indicative of local joint pathology rather than systemic influences when considering posterior horn meniscal grade. Although age demonstrated a weak positive correlation with meniscal grade in the univariate analysis, this association disappeared after adjustment for Hoffa fat pad morphology and other covariates. This finding suggests that local structural alterations within the knee joint may have a stronger relationship with grade severity than chronological age alone.

No significant differences in Hoffa fat pad morphology were observed between isolated medial and combined medial plus lateral posterior horn involvement. However, the combined involvement group was small and consisted exclusively of patients with higher MRI grades. Therefore, this comparison should be interpreted with caution, and further studies including larger numbers of patients with combined involvement are warranted.

Limitations

There are several limitations to be taken into account. First, the retrospective design of the study has potential for selection bias and does not allow for causal inference. Furthermore, because the study employed a grade-balanced sampling strategy, the regression-derived ORs represent adjusted associations within the selected cohort rather than population-level risk estimates or predictive performance. Second, the quantitative analysis was limited to single-slice sagittal parameters (thickness and CSA) rather than multislice or three-dimensional volumetric tracking. This strategy was intentionally chosen in view of the practical feasibility in routine clinical practice; however, it is still at a risk of slice-selection bias and underestimation of general volumetric discrepancy. Third, a single radiologist performed all image analyses; thus, interobserver variability was not assessed, constituting a methodological weakness for an operator-dependent manual tracing technique. Fourth, in patients who underwent bilateral knee MRI examinations, only one knee was included in the analysis, and the knee with the higher MRI-based posterior horn meniscal grade was selected. This approach may have introduced selection bias toward more advanced structural abnormalities. Fifth, our assessment focused entirely on the posterior horn segments of the menisci; consequently, potential structural cross-talk originating from isolated anterior horn or meniscal body pathologies was not thoroughly analyzed. Sixth, our cohort lacked specific patient-reported clinical metrics (such as visual analog scale or WOMAC scores) and radiographic osteoarthritis classifications (such as Kellgren-Lawrence grading). Although patients with severe osteoarthritis and significant cartilage degeneration were excluded, early or subclinical osteoarthritic changes not detectable on routine MRI may still have influenced Hoffa fat pad morphology. Therefore, residual confounding related to underlying osteoarthritic changes cannot be completely excluded. Finally, without histopathological correlation, we cannot verify the tissue composition and inflammatory state of the Hoffa fat pad. Future prospective studies involving larger and more heterogeneous populations, naturally distributed MRI-based posterior horn meniscal grades, isolated lateral meniscal abnormalities, and interobserver validation are warranted to confirm and extend the present findings.

CONCLUSION

Our findings demonstrate that Hoffa fat pad morphology, particularly sagittal CSA, is inversely associated with MRI-based posterior horn meniscal grade. Among the evaluated imaging parameters, Hoffa fat pad CSA remained independently associated with higher MRI-based posterior horn meniscal grade after adjustment for demographic variables. These findings suggest that Hoffa fat pad CSA may serve as a useful MRI-derived morphological marker associated with structural meniscal abnormalities. However, because of the retrospective cross-sectional design, intentional grade-balanced sampling strategy, and absence of interobserver validation, the observed associations should not be interpreted as evidence of causality, predictive performance, or population-level risk. Prospective longitudinal studies are needed to confirm these findings and determine their clinical applicability.

DECLARATIONS

Ethics Committee Approval: The study protocol was approved by the Gaziantep University Ethics Committee (No: 2026/139, Date: 18/02/2026).

Informed Consent: Due to the retrospective study design, the requirement for informed consent was waived.

Conflict of Interest: The authors declare that there is no conflict of interest.

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