

# Development of Mucoïd Degeneration of the Anterior Cruciate Ligament is Associated with Intermediate-term Outcomes after High Tibial Osteotomy: A Propensity Score-Matched Analysis

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INTRODUCTION:

Mucoïd degeneration (MD) of the anterior cruciate ligament (ACL) is a recognized pathology marked by collagen fiber degradation and infiltration of a mucoïd substance, which may serve as a precursor to knee osteoarthritis. This study aimed to investigate the association between progressive MD-ACL and intermediate-term outcomes following high tibial osteotomy (HTO) for medial compartment knee osteoarthritis.

## METHODS:

We identified 322 patients who underwent medial opening-wedge HTO for medial compartment osteoarthritis with intact ACL between 2015 and 2022. All patients underwent second-look arthroscopy approximately two years after the initial HTO, with a mean follow-up duration from the initial HTO to the latest evaluation of 72.5 months (range, 27.0–116.0). Patients with MD-ACL observed during second-look arthroscopy were classified as the MD-ACL group, while those with a normal ACL served as the control group. Propensity score matching was conducted based on age, sex, body mass index, and the interval between HTO and second-look arthroscopy, resulting in 43 matched patients in each group.

## RESULTS:

Both groups showed significant improvements in clinical outcomes at second-look arthroscopy compared to baseline (all  $p < 0.001$ ). However, the MD-ACL group had significantly worse International Knee Documentation Committee (IKDC) scores, Knee Injury and Osteoarthritis Outcome Score subscales (pain, symptoms, activities of daily living), and range of motion compared to the control group at second-look arthroscopy ( $p < 0.05$ ). At the latest follow-up, outcomes in the control group remained stable without significant decline ( $p = 0.568$ ), while the MD-ACL group demonstrated a clear tendency toward deterioration ( $p = 0.025$ ), including a significant decline in IKDC scores. The survival rate at a mean follow-up of 72.5 months was 97.6%, with no significant difference between groups ( $p = 0.400$ , log-rank test). Multivariate regression analysis identified smaller intercondylar notch geometry ( $p = 0.003$ ), increased postoperative medial proximal tibial angle (MPTA) ( $p = 0.031$ ), and larger changes in posterior tibial slope ( $\Delta$ PTS) ( $p = 0.004$ ) as significant predictors of MD-ACL development.

**DISCUSSION AND CONCLUSION:** The development of MD-ACL was associated with poorer clinical outcomes following HTO over an intermediate-term follow-up period. Smaller intercondylar notch geometry, increased MPTA, and larger  $\Delta$ PTS were significant predictors of MD-ACL development. These findings highlight the importance of careful preoperative planning and meticulous attention to surgical techniques that avoid excessive increases in MPTA and PTS, thereby improving outcomes.

## HTO



Figure 1. Arthroscopic images of ACL. (Left) Normal ACL. (Right) ACL with mucoïd degeneration (MD). Scale bar: 1 cm.

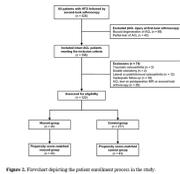


Figure 2. Flowchart depicting the patient selection process in the study.

**Table 1. Baseline Characteristics of the Study Population**

Characteristic	MD-ACL Group (n=43)	Control Group (n=43)
Age (mean ± SD)	58.2 ± 10.5	57.8 ± 11.2
Sex (Male/Female)	32/11	31/12
Body Mass Index (mean ± SD)	24.5 ± 3.2	24.8 ± 3.5
Interval between HTO and second-look arthroscopy (mean ± SD)	72.5 ± 25.3	71.8 ± 26.1

**Table 2. Comparison of Clinical Outcomes between MD-ACL and Control Groups**

Outcome	MD-ACL Group (n=43)	Control Group (n=43)
IKDC Score (mean ± SD)	68.5 ± 12.3	75.2 ± 10.8
Knee Injury and Osteoarthritis Outcome Score (mean ± SD)	45.2 ± 15.1	52.8 ± 13.5
Range of Motion (mean ± SD)	115.3 ± 8.7	122.1 ± 7.9

**Table 3. Regression Analysis of Risk Factors for MD-ACL Development**

Risk Factor	OR	95% CI	p-value
Smaller intercondylar notch geometry	1.8	1.2–2.7	0.003
Increased postoperative MPTA	1.5	1.0–2.2	0.031
Larger $\Delta$ PTS	1.3	1.0–1.7	0.004

**Table 4. Survival Analysis of the Study Population**

Group	Survival Rate at 72.5 months (%)
MD-ACL Group	97.6
Control Group	98.1

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