

Extent of Preoperative Medial Meniscal Extrusion Influences Intermediate-Term Outcomes After Medial Opening-Wedge High Tibial Osteotomy

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INTRODUCTION

High Tibial Osteotomy (HTO)

❖ **HTO is considered as the primary treatment for medial compartmental knee osteoarthritis**

- Medial opening HTO (MOHTO) becomes popular
 - ✓ Firm fixation devices
 - ✓ Improvement of technique
- Long-term: 74 to 92% survival rates at 10 years

Lobenhoffer P et al. Knee Surg Sports Traumatol Arthrosc 2003

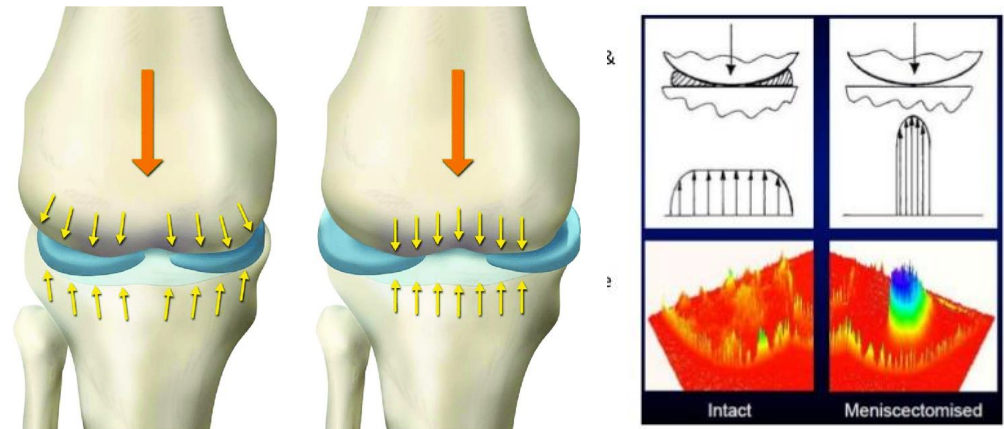
Duivenvoorden T et al. J Bone Joint Surg Am 2014

Medial Meniscus

❖ Medial meniscus

- Crucial role in the knee

- ✓ Load distribution
- ✓ Lubrication
- ✓ Stabilization
- ✓ Shock absorption
- ✓ Proprioception



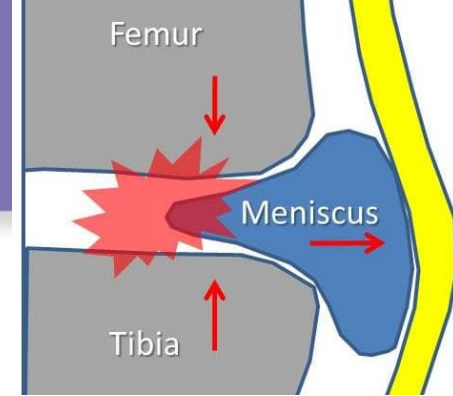
- Damage to the meniscus disrupts structural integrity and alter the weight-bearing capacity of the knee joint

Villegas DF et al. Ann Biomed. 2008

Hunter DJ et al. Arthritis Rhe. 2006

Englund M et al. Ann Rhe. 2010

Medial Meniscus Extrusion



❖ Medial meniscus Extrusion (MME)

- Extruded: extend to the periphery beyond the tibial plateau
- Loss of hoop tension → Pathologic loads → Progression of OA

Lee SJ et al. AM J Sports Med. 2006

Berthiaume MJ. Ann Rheum Dis. 2005

❖ Clinical relevance

- Pathologic MME: presence of MME > 3mm
- Defined as an important predictor for OA

Costa CR et al. AJR Am J Roentgenol 2004

Renn WJ et al. AJR AM J Roentgenol 2006

Purpose

- ❖ **Clarify the association between preoperative MME severity and clinical outcomes and survival after MOHTO over a mid-term follow-up**

- ❖ **Hypothesis: Severe MME would correlate with worse outcomes**

METHODS

Patients

❖ 262 HTO cases from 2009 to 2014

❖ Inclusion criteria

- Patients who underwent MOHTO with a minimum follow-up of 5 yrs
- Preoperative MRI scans taken within 6 months

❖ Exclusion criteria

- ROM < 120°, Flexion contracture > 15°
- Degenerative on lateral, patellofemoral compartment
- Ligament insufficiency
- Additional cartilage procedures (OATS, ACI, BMAC, Cartistem)

MRI Assessment

❖ Common methods

- 1st Method: Presence or absence of pathologic MME
- 2nd Method: MRI Osteoarthritis Knee Score (MOAKS) criteria
- 3rd Method: Relative value based on the method of Puig L et al.

Costa CR et al. Am J Roentgenol. 2004

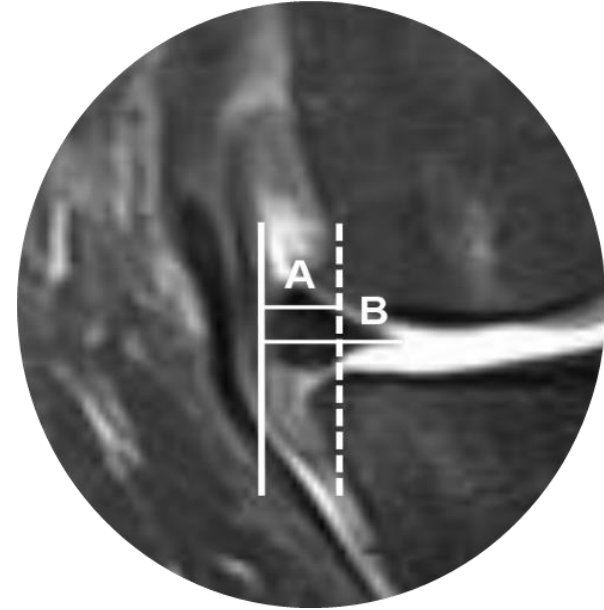
Puig L et al. KSSTA. 2006

Choi CJ et al. Arthroscopy. 2010

Kim MS. Am J Sports Med. 2020

❖ Inter-rater reliability: intraclass correlation coefficient (ICC)

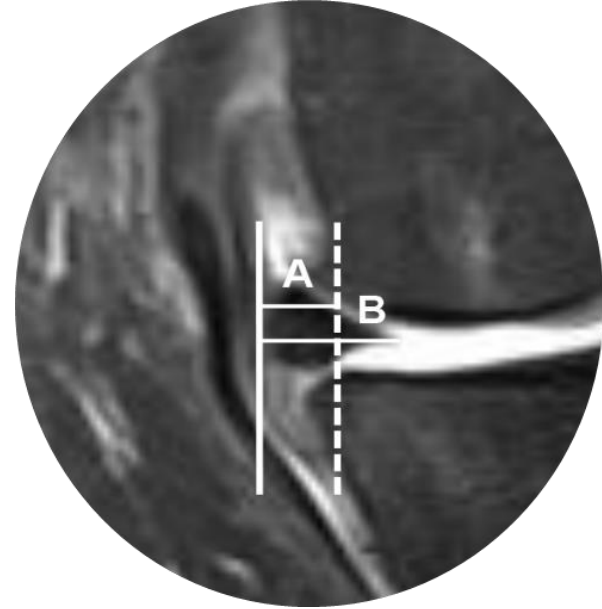
MRI Assessment (Absolute)



❖ Reference

- Midportion of medial femoral condyle
- White dashed line : Medial margin of MTP
- White line: Peripheral edge of medial meniscus
- Between 2 lines: Absolute value (A)

MRI Assessment (Relative)



❖ Reference

- A: Absolute value between 2 lines
- B: Whole width of medial meniscus
- $(A/B) \times 100$: Relative meniscal extrusion

MRI Assessment

❖ MOAKS criteria (absolute value of MME)

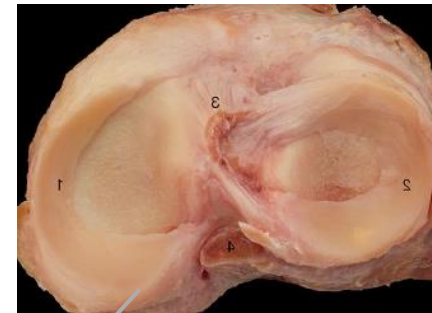
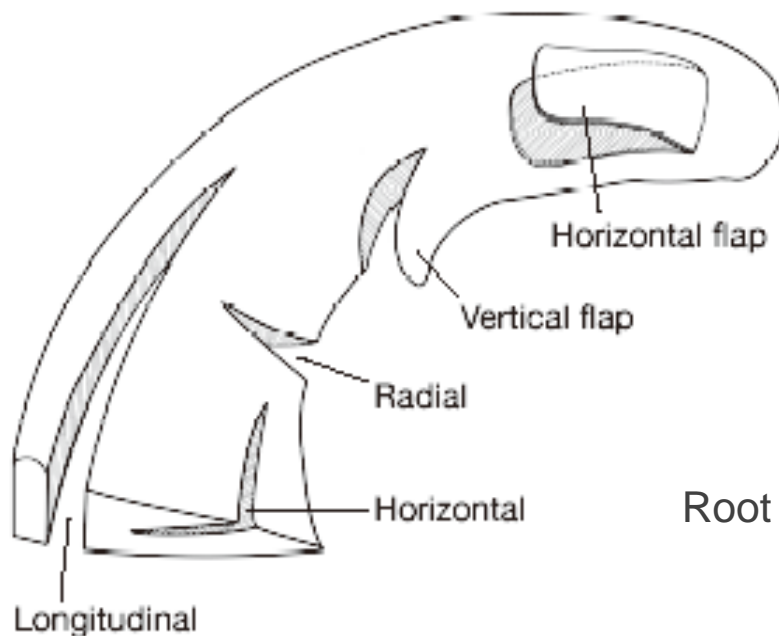
- Grade 0: $< 2.0\text{mm}$
- Grade 1: 2.0 to 2.9mm
- Grade 2: 3.0 to 4.9mm
- Grade 3: $\geq 5.0\text{mm}$

❖ Relative value of MME

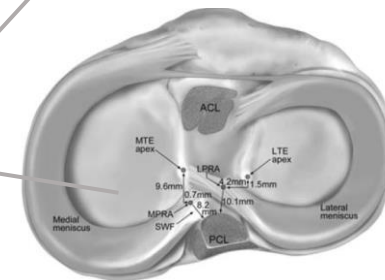
- Grade 1: $< 25\%$
- Grade 2: 25 to $< 50\%$
- Grade 3: 50% to $< 75\%$
- Grade 4: $\geq 75\%$

Meniscus Evaluation

❖ International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Classification



Root tear



Smigielski R et al. KSSTA 2015

LaPrade F et al AJSM 2012

Anderson et al. AJSM. 2011

Clinical Assessment

❖ Knee Injury and Osteoarthritis Outcome Score (KOOS)

- Pain
- Symptoms
- Activities of daily living (ADL)
- Sports and recreation
- Quality of life (QOL)

❖ Tegner activity scale score

Radiographic Assessment

- ❖ **Mechanical hip-knee ankle axis (HKA) angle**
- ❖ **Posterior tibial slope**
- ❖ **Medial proximal tibial angle (MPTA)**
- ❖ **Kellgren-Lawrence grade**

Statistical Analysis

- ❖ **Wilcoxon signed rank test / Mann-Whitney U test**
 - Non-normally distributed variables
- ❖ **Spearman rank-correlation with each reviewer's grading**
 - To evaluate associations between MME severity and outcomes
- ❖ **Kaplan-Meier survival analysis with log-rank test**
 - Conversion to total knee arthroplasty (TKA) was the endpoint

RESULTS

Demographic Characteristics

Female [<i>no. (%)</i>]	171 (80.6% of 212)
Age (<i>yr</i>)	56.3 ± 4.8
Operation side, left [<i>no. (%)</i>]	114 (53.7)
Mean follow-up [†] (<i>yr</i>)	8.1 ± 2.0
BMI* (<i>kg/m²</i>)	25.3 ± 2.6
Preoperative K-G scale	2.6 ± 0.5
Preoperative HKA angle* [‡] (<i>deg</i>)	6.8 ± 2.6
Preoperative posterior tibial slope* (<i>deg</i>)	8.7 ± 3.7
Preoperative MPTA* (<i>deg</i>)	85.5 ± 3.1
Postoperative HKA angle* [‡] (<i>deg</i>)	-1.5 ± 3.1
Postoperative posterior tibial slope* (<i>deg</i>)	9.1 ± 3.9
Postoperative MPTA* (<i>deg</i>)	92.2 ± 2.9

Medial Meniscal Characteristics

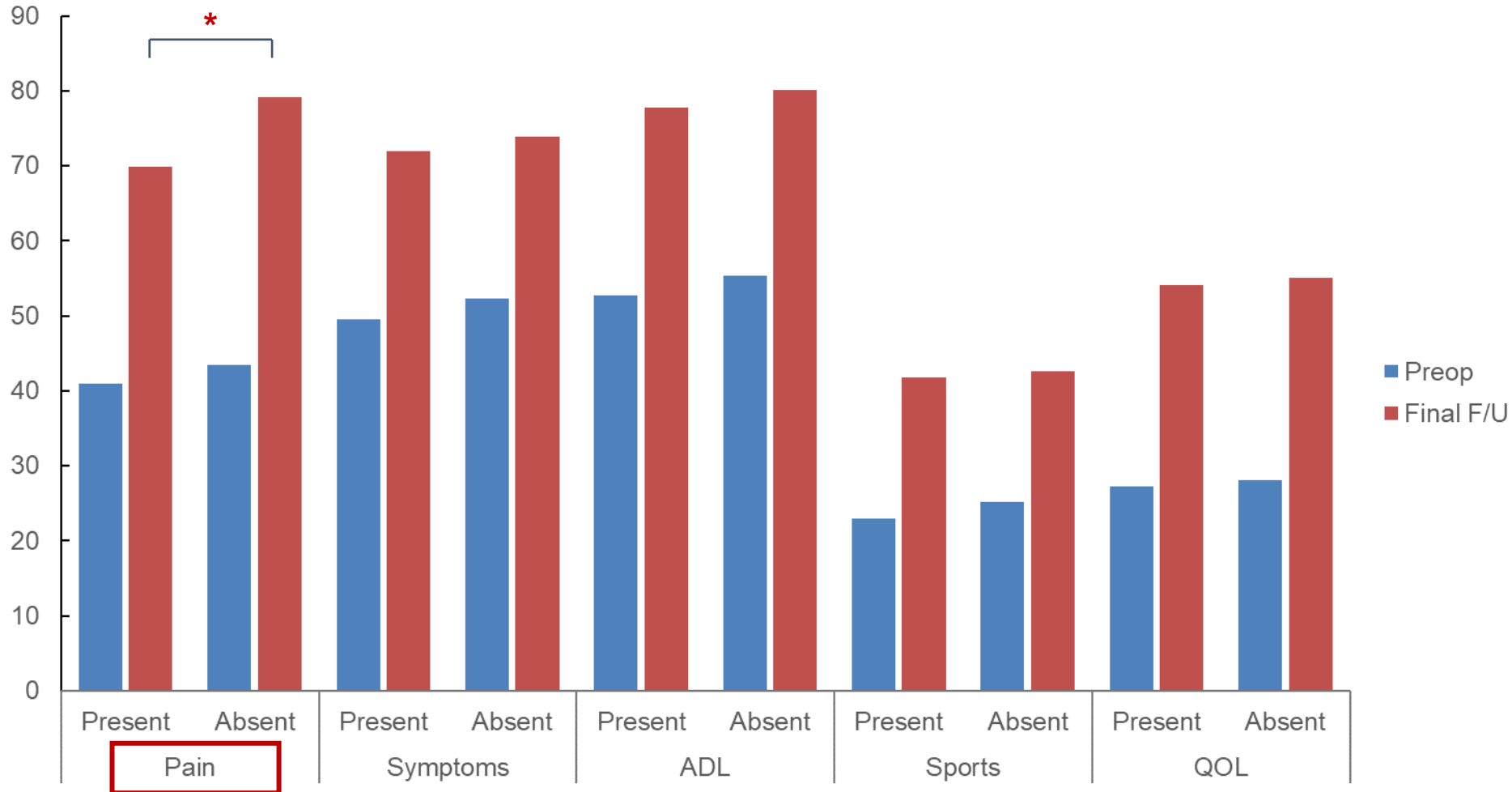
Variable	
Absolute value of meniscal extrusion	4.0 ± 1.6
Relative value of meniscal extrusion, % [†]	37.6 ± 19.1
Location of meniscal tear	
Posterior horn	121 (58.2)
Midbody	15 (7.2)
More than 1 portion	72 (34.6)
Pattern of meniscal tear	
Longitudinal tear	4 (1.9)
Horizontal tear	22 (10.4)
Vertical flap tear	5 (2.4)
Radial tear	9 (4.2)
Horizontal flap tear	51 (24.1)
Complex tear	63 (29.7)
Root tear	54 (25.4)
No tear	4 (1.9)

Relevant Factors for MME

Preoperative Variable	Univariate Analysis		Multivariate Analysis	
	Estimate (95% CI)	P Value*	Estimate (95% CI)	P Value†
Sex (female vs male)	-0.034 (-0.594 to 0.525)	0.904		
Age	0.015 (-0.031 to 0.061)	0.517		
BMI	0.065 (-0.017 to 0.147)	0.121		
Location of meniscal tear		0.838		
Posterior horn vs no tear	1.629 (0.003 to 3.254)	0.050		
Midbody vs no tear	1.394 (-0.406 to 3.193)	0.128		
More than 1 portion vs no tear	1.748 (0.105 to 3.390)	0.037		
Pattern of meniscal tear		0.001		0.001
Longitudinal tear vs no tear	0.885 (-1.198 to 2.968)		0.618 (-1.344 to 2.580)	
Horizontal tear vs no tear	0.380 (-1.222 to 1.981)		0.428 (-1.078 to 1.935)	
Vertical flap tear vs no tear	-0.517 (-2.493 to 1.460)		0.410 (-2.269 to 1.450)	
Radial tear vs no tear	0.712 (-1.059 to 2.483)		0.653 (-1.013 to 2.318)	
Horizontal flap tear vs no tear	2.287 (0.757 to 3.817)		2.109 (0.668 to 3.549)	
Complex tear vs no tear	1.736 (0.217 to 3.255)		1.507 (0.076 to 2.938)	
Root tear vs no tear	1.890 (0.363 to 3.417)		1.791 (0.355 to 3.227)	
K-L grade		<0.001		<0.001
Grade 3 vs grade 2	1.227 (0.801 to 1.652)		1.165 (0.735 to 1.620)	
HKA angle	-0.004 (-0.087 to 0.080)	0.929		
Posterior tibial slope	-0.024 (-0.836 to 0.034)	0.416		

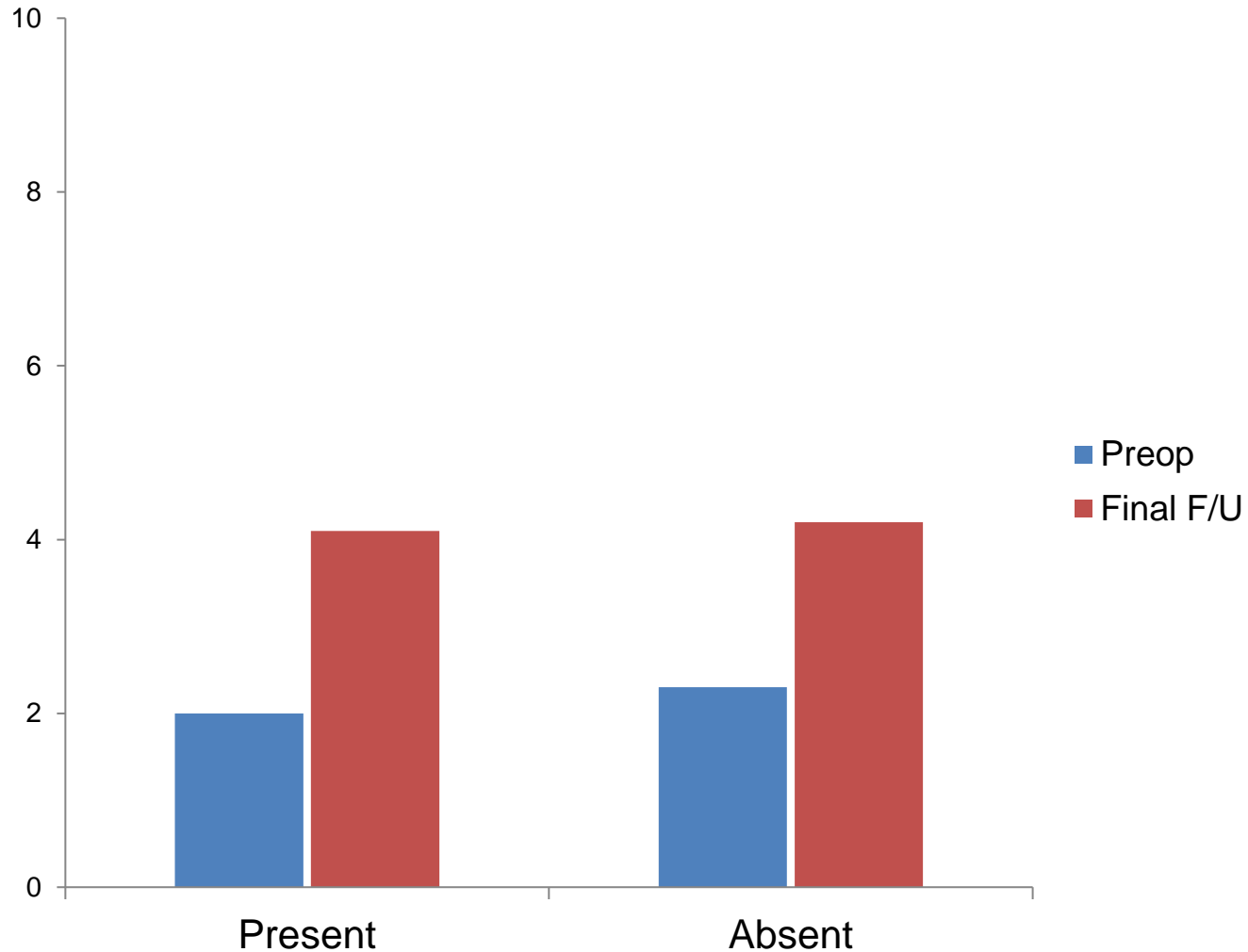
Meniscus pattern & progressed KL grade relate to MME

KOOS Score Based on Pathologic MME



Significant differences between pre and postoperative results

Tegner Score Based on Pathologic MME



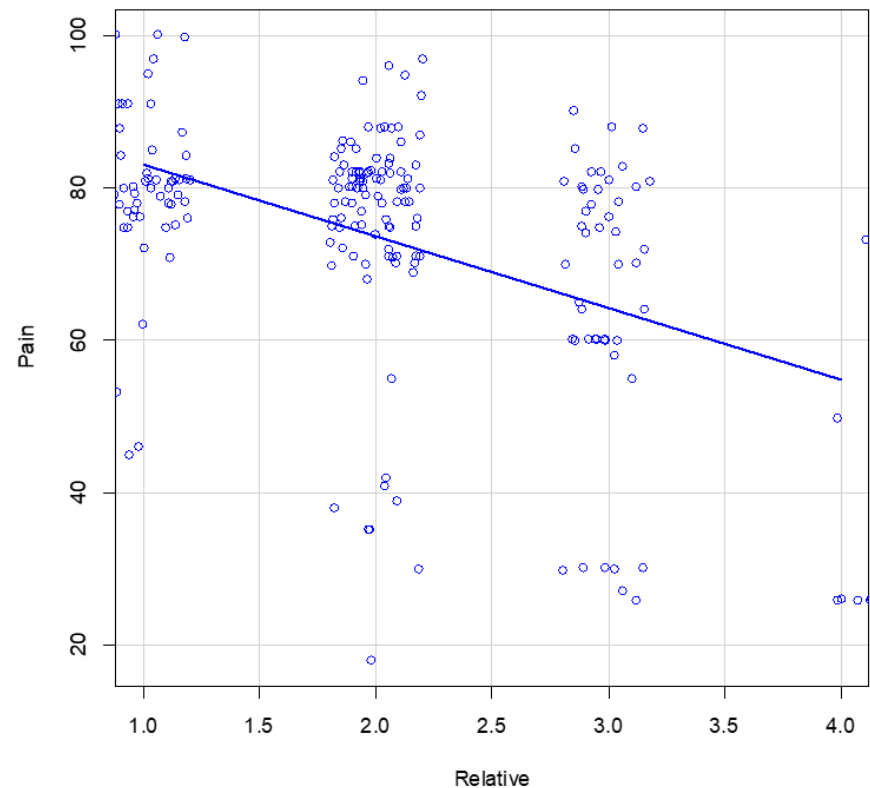
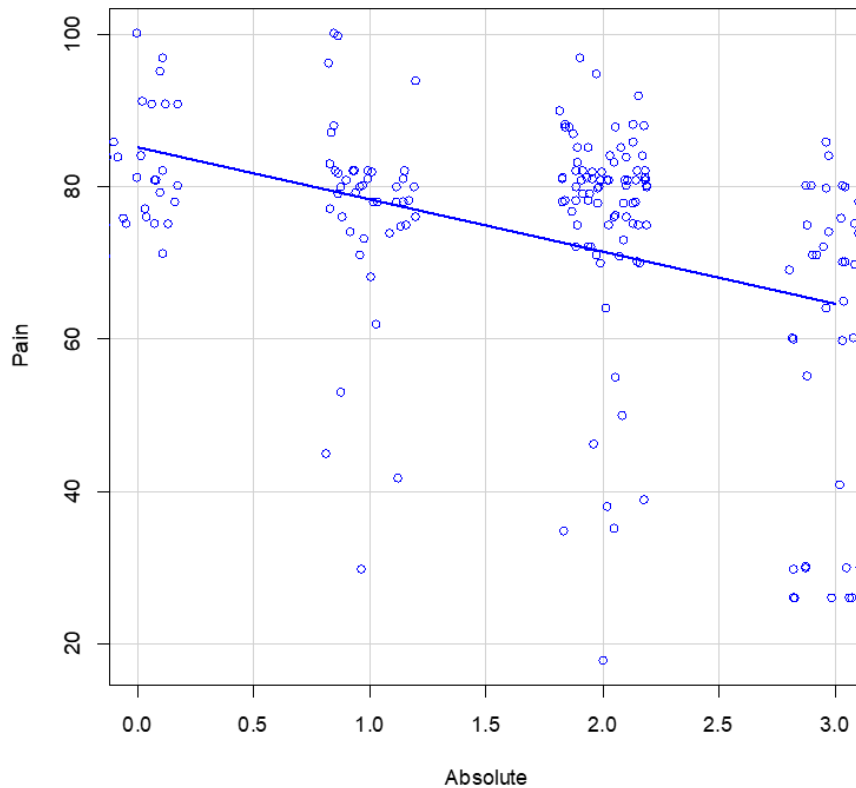
No differences between postoperative results between groups

Correlation btw MME and Outcomes

	Results*		P Value‡	Spearman's Correlation with MME Pattern†	
	Preoperative	Final Follow-up		Absolute Value	Relative Value
KOOS					
Pain	41.8 ± 7.1	73.3 ± 16.0	<0.001	-0.404 (<0.001)	-0.364 (<0.001)
Symptoms	50.5 ± 7.5	72.6 ± 11.1	<0.001	-0.118 (0.086)	-0.071 (0.306)
Activities of daily living	53.6 ± 6.0	78.6 ± 11.6	<0.001	-0.092 (0.183)	-0.119 (0.085)
Sports and recreation	23.7 ± 5.7	42.1 ± 13.6	<0.001	-0.067 (0.333)	-0.050 (0.473)
Quality of life	27.6 ± 6.0	54.4 ± 14.1	<0.001	-0.095 (0.167)	-0.020 (0.775)
Tegner Activity Scale Score	2.1 ± 0.5	4.2 ± 1.2	<0.001	-0.065 (0.349)	-0.052 (0.448)

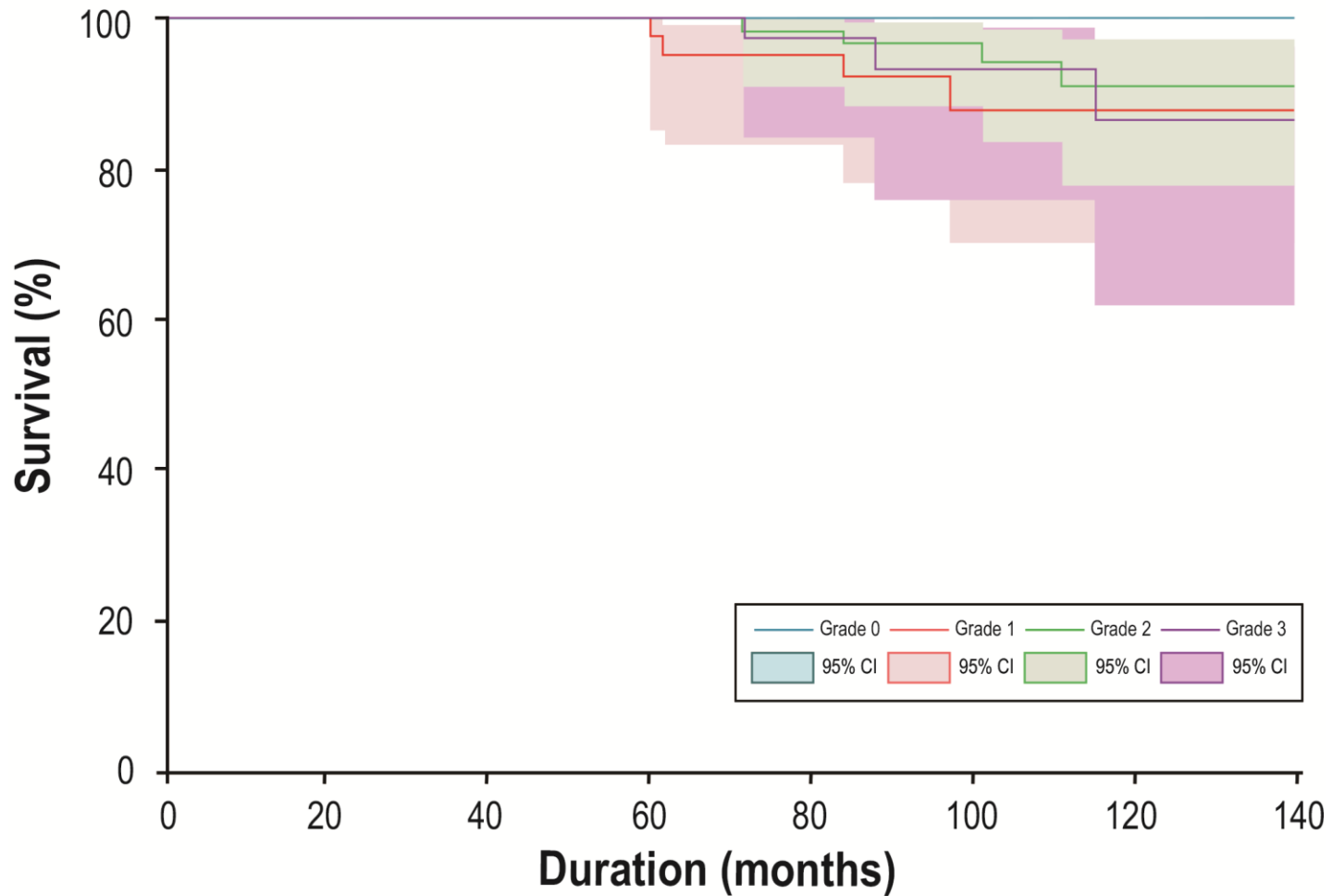
Significant correlation was found between MME extent and postoperative KOOS pain based on both classification

Correlation btw MME and Outcomes



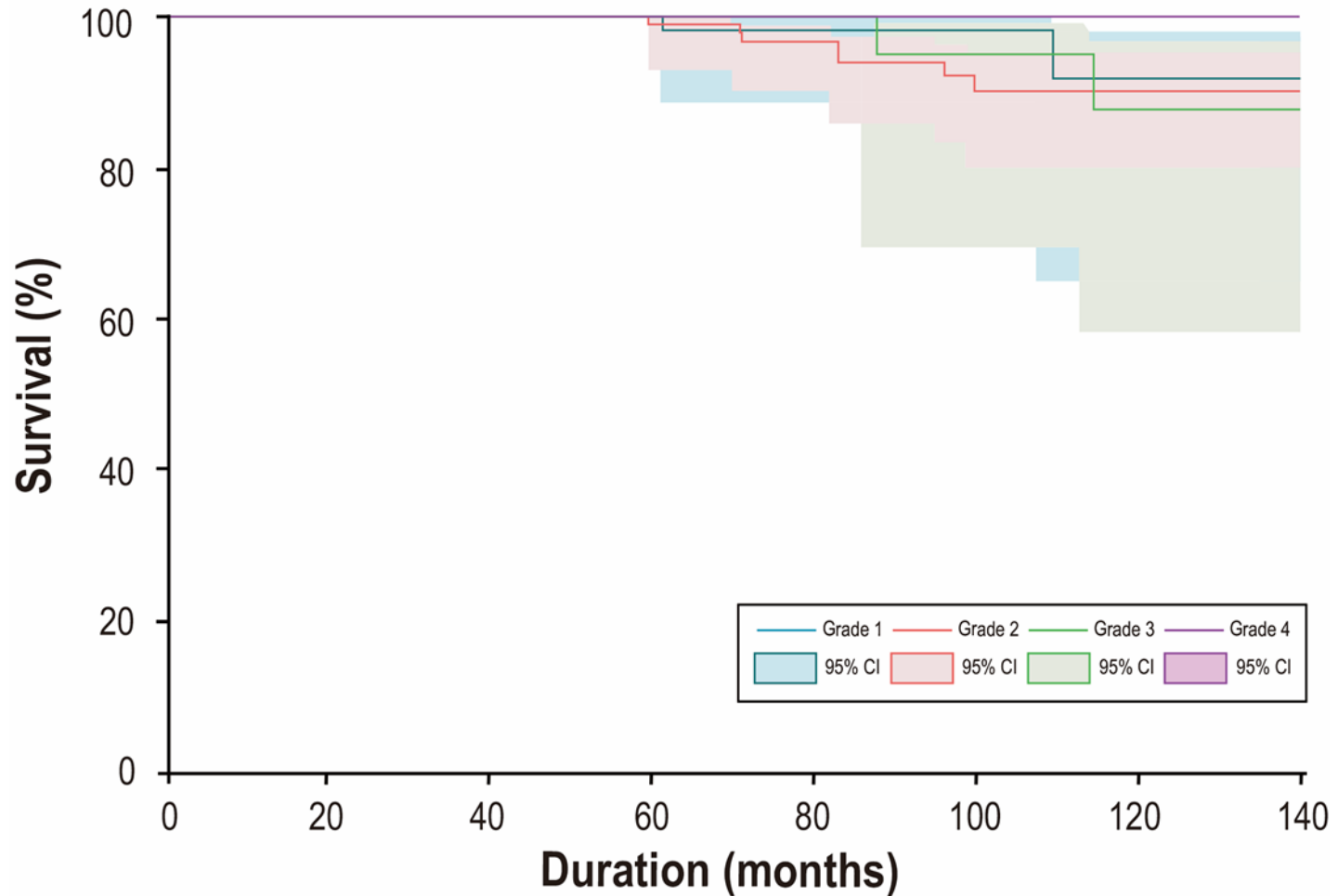
Negative correlation was found between MME extent and postoperative KOOS pain based on both classification

Survival Analysis



No differences in survival rates according to MME grade (P = 0.363)

Survival Analysis



No differences in survival rates according to MME grade (P = 0.741)

CONCLUSIONS

Takeaway

- ❖ **Extent of preoperative MME can be pathological and were associated with adverse HTO outcomes**
 - Patients with pathologic MME: Inferior clinical scores
 - Greater severity of MME: Negative correlation with scores

- ❖ **MOHTO showed improvement of MME distance as well as clinical outcomes at midterm follow-up, however a large-scale future study is needed to elucidate the correlation between these factors**

Thank You

