Optimal Knee Alignment During Medial Opening Wedge High Tibial Osteotomy for Medial Meniscus Posterior Root Tear: A Biomechanical Cadaveric Study

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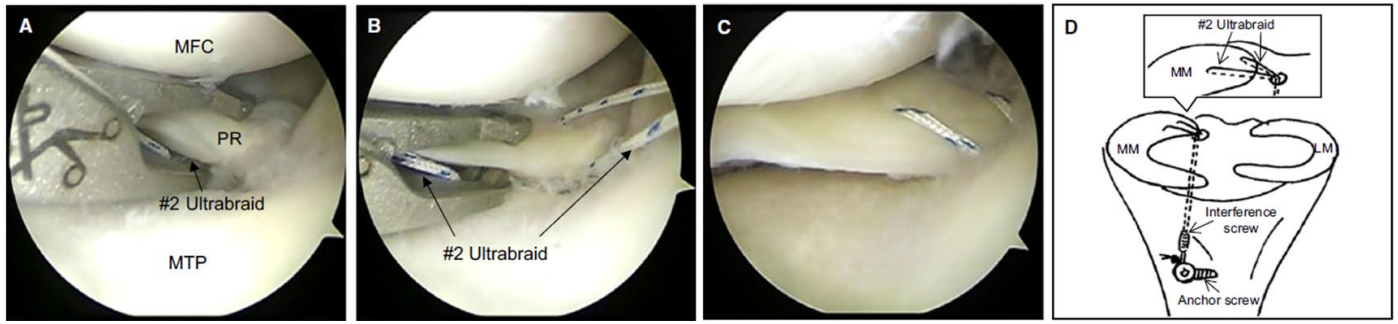
Disclosure of Conflict of Interest

We have nothing to declare for this study.

Introduction: treatment of medial meniscus posterior root tear (MMPRT)

- Transtibial pullout repair of MMPRT is a common treatment



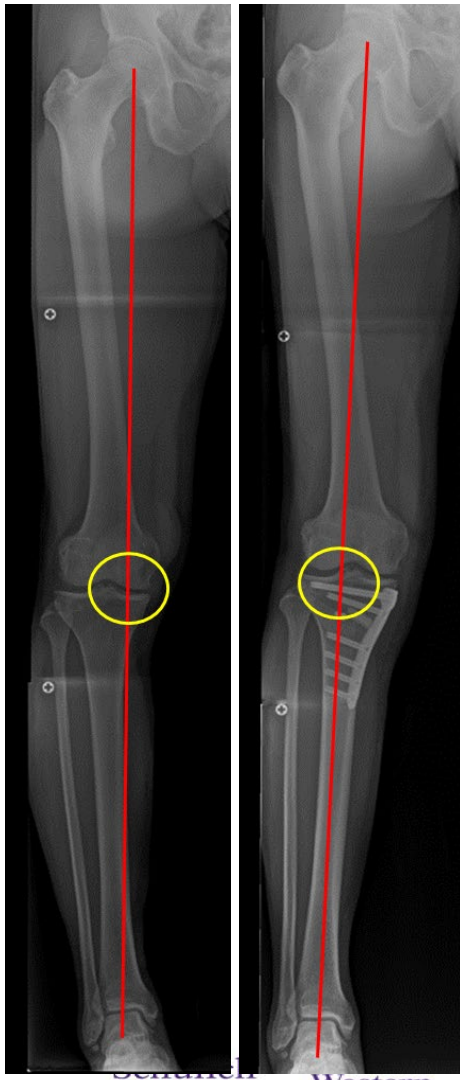
- Varus knee alignment is associated with suboptimal outcomes

Chung et al. Arthroscopy 2016

- MOWHTO is used for MMPRT with varus alignment

Chung et al. KSSTA 2021

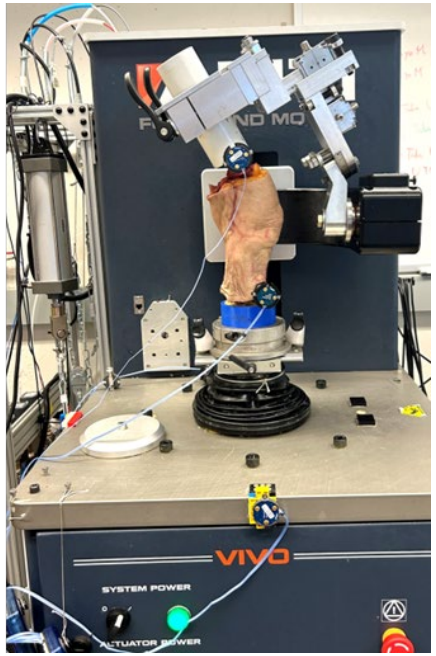
- Optimal knee alignment for MMPRT with varus alignment remains unclear



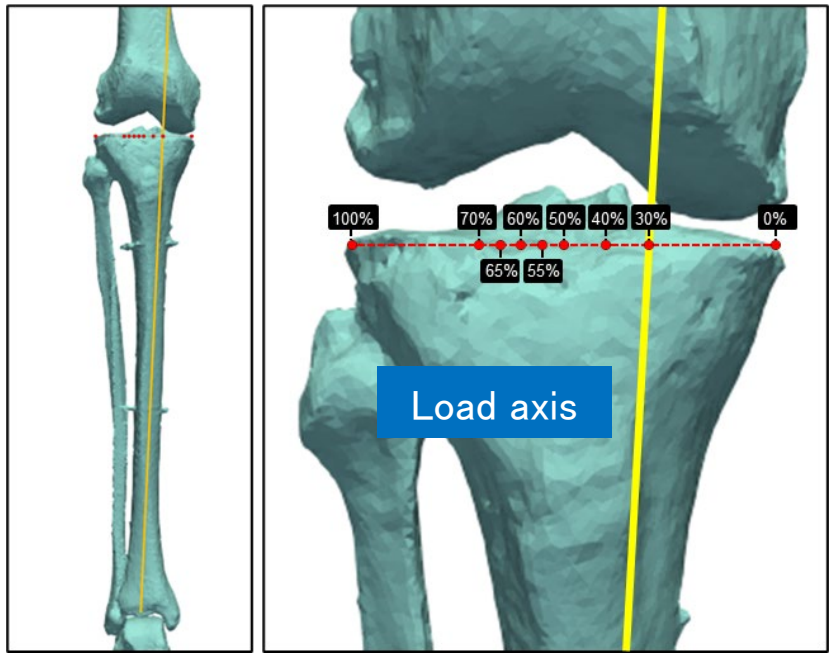
Purpose to determine the **optimal biomechanical knee alignment** for treating MMPRT during MOWHTO

Methods: mechanical testing system

- 10 fresh–frozen whole human cadaveric legs
- Simulate a mechanical axis load using the VIVO joint motion simulator
- %WBL method: loads shift from 30% to 70%



VIVO joint motion simulator



%WBL method

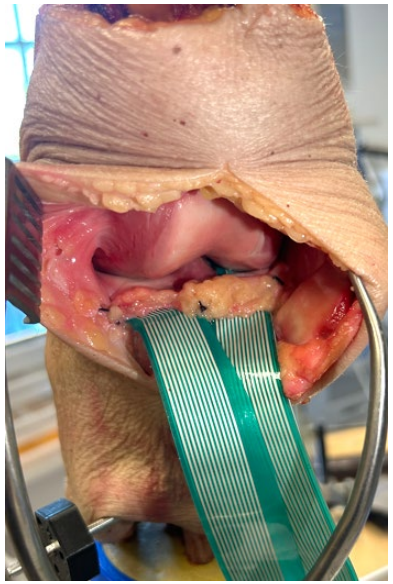
Methods: tibiofemoral cartilage pressure assessment

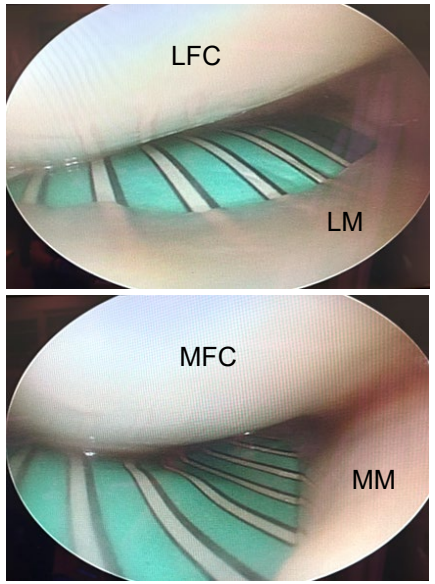
- Insert the pressure sensors (K-Scan System model 4011; Tekscan)
- K-Scan sensor is inserted between the tibial plateau and the undersurface of MM and LM.
- Apply 700 N load for 30 seconds

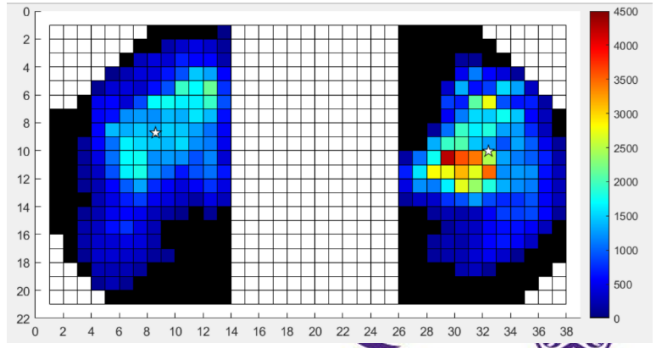
Shimakawa et al. OJSM 2019

- Measure the peak contact pressure (PCP), mean contact pressure (MCP), and contact area (CA).

Pressure sensor insertion

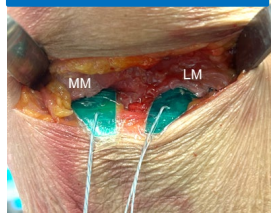






Methods: study protocol

Intact

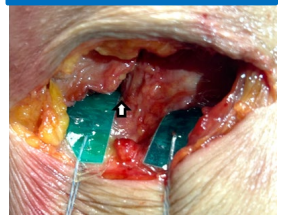


①

Intact knee (control)

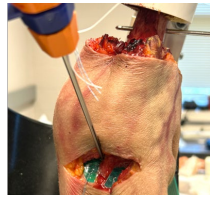
Root cut

MMPRT



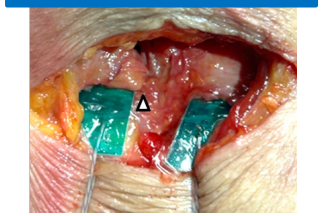
②

MMPRT knee



Root repair
(suture anchor)

MMPRT repair



③

MMPRT repair knee

700 N load in extension

Evaluate
PCP, MCP, and CA
across different alignments

700 N load in extension

Evaluate
PCP, MCP, and CA
across different alignments

700 N load in extension

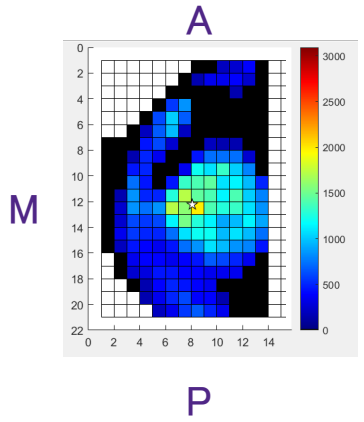
Evaluate
PCP, MCP, and CA
across different alignments

Shift the load axis **from 30% to 70% WBL** (30%, 40%, 50%, 55%, 60, 65%, 70%)

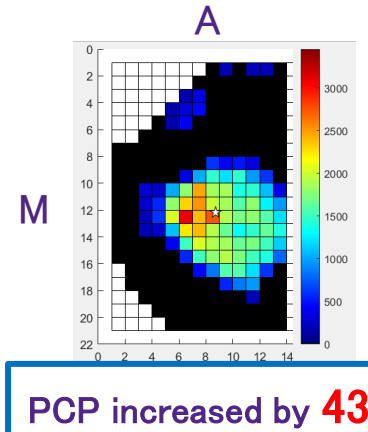
Result: peak contact pressure (PCP) in medial compartment

Medial

Intact (%WBL=50%)

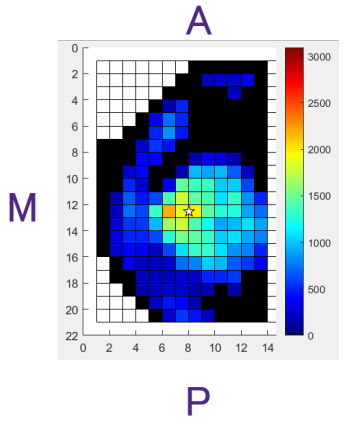


MMPRT (%WBL=50%)

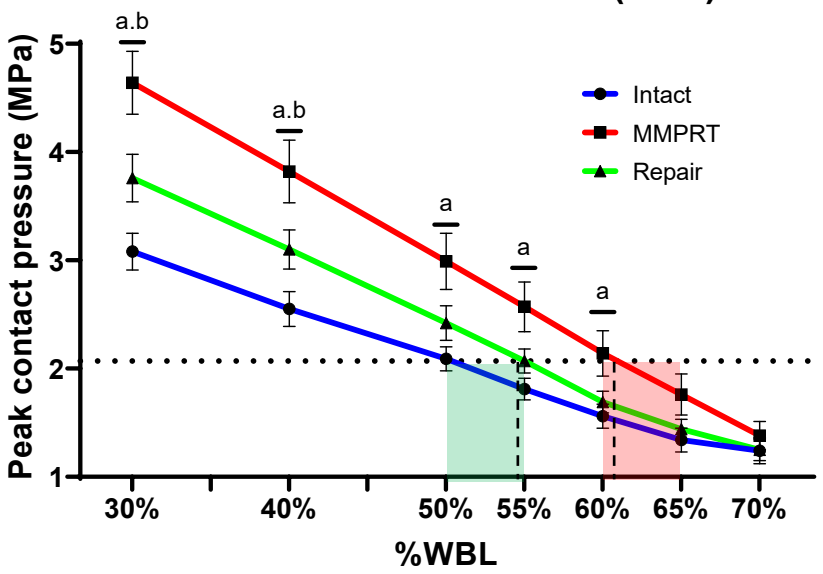


PCP increased by 43%

MMPRT repair (%WBL=50%)



Peak Contact Pressure (MPa)



a Statistical significance ($p<0.05$) in the intact versus MMPRT conditions.
b Statistical significance ($p<0.05$) in the MMPRT versus repair condition.

Comparison of PCP among the three conditions (MPa)

%WBL (%)	30	40	**50**	**55**	**60**	**65**	70
Intact (MPa)	3.1	2.6	**2.1**	1.8	1.6	1.3	1.2
MMPRT(MPa)	4.6	3.8	3.0	2.6	**2.1**	**1.8**	1.4
Repair (MPa)	3.8	3.1	**2.4**	**2.1**	**1.7**	1.4	1.3

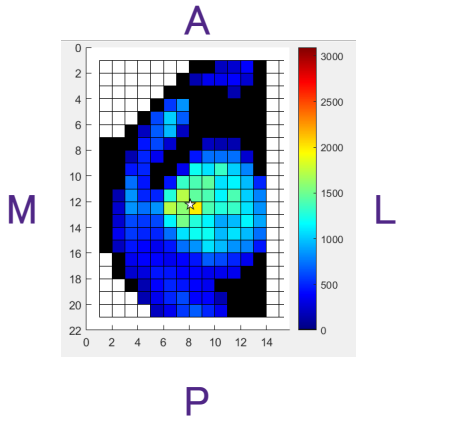
PCP, peak contact pressure

PCP at neutral alignment in intact knee is equal to
PCP at 60–65% in MMPRT knee
PCP at 50–55% in MMPRT repair knee

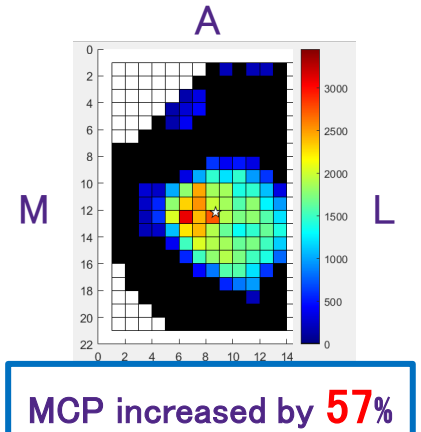
Result: mean contact pressure (MCP) in medial compartment

Medial

Intact (%WBL=50%)

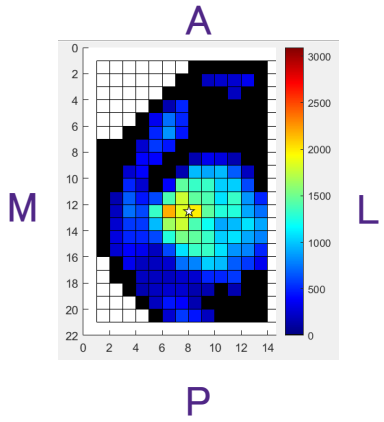


MMPRT (%WBL=50%)

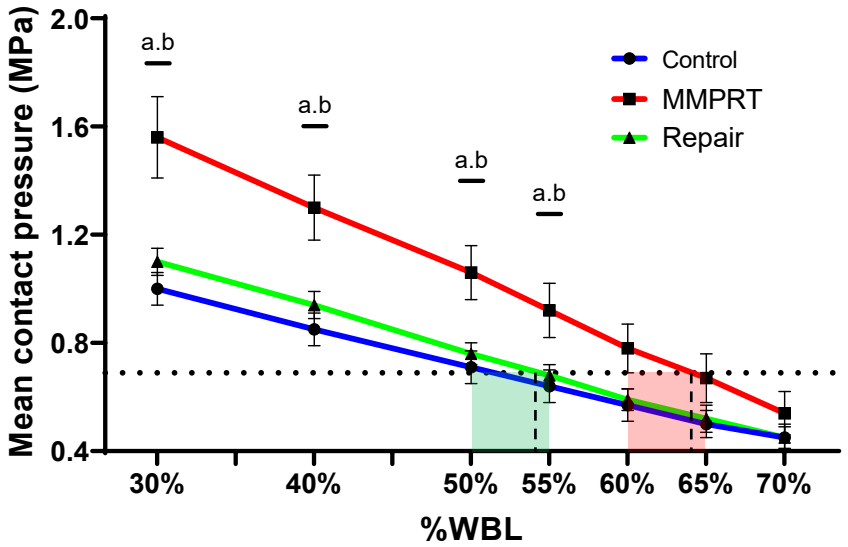


MCP increased by 57%

MMPRT repair (%WBL=50%)



Mean Contact Pressure (MPa)



a Statistical significance ($p<0.05$) in the intact versus MMPRT conditions.
b Statistical significance ($p<0.05$) in the MMPRT versus repair condition.

Comparison of MCP among the three conditions (MPa)

%WBL (%)	30	40	**50**	**55**	**60**	**65**	70
Intact (MPa)	1.0	0.9	**0.7**	0.6	0.6	0.5	0.5
MMPRT(MPa)	1.6	1.3	1.1	0.9	**0.8**	**0.7**	0.5
Repair (MPa)	1.1	0.9	**0.8**	**0.7**	0.6	0.5	0.5

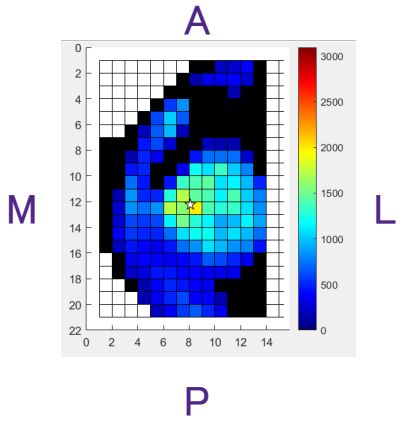
MCP, mean contact pressure

MCP at neutral alignment in intact knee is equal to
MCP at 60–65% in MMPRT knee
MCP at 50–55% in MMPRT repair knee

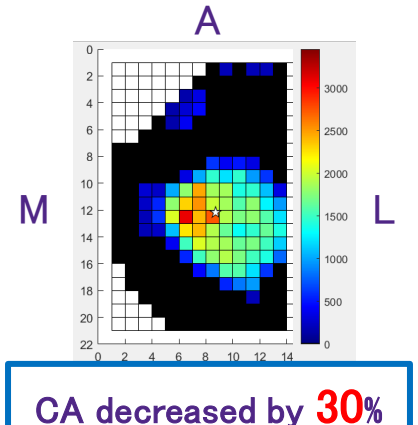
Result: contact area (CA) in medial compartment

Medial

Intact (%WBL=50%)

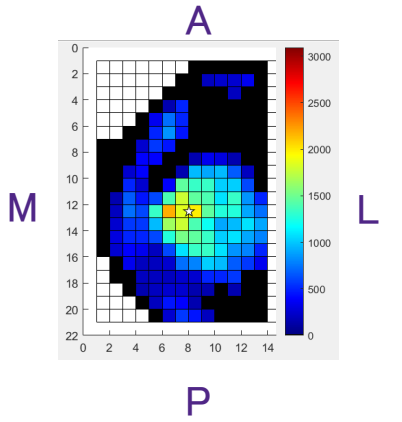


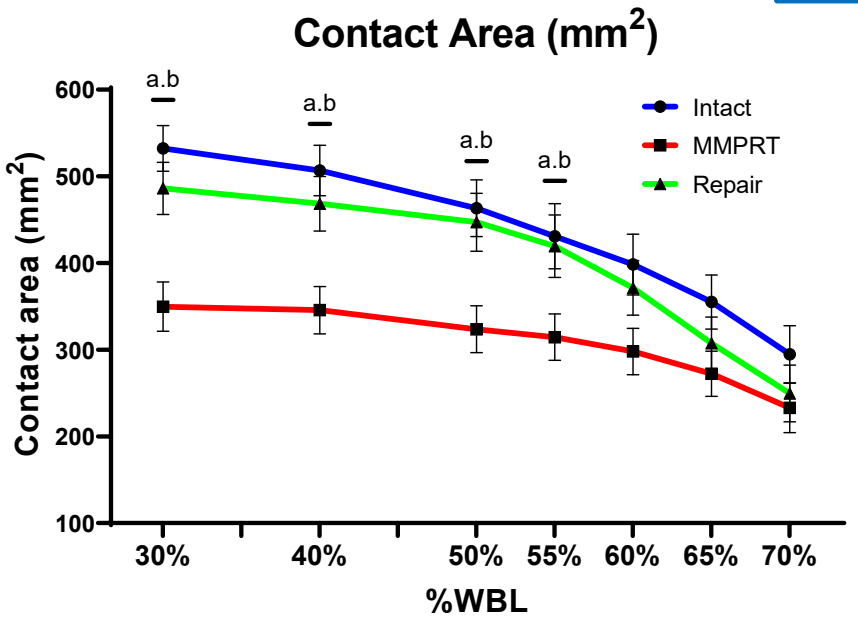
MMPRT (%WBL=50%)



CA decreased by 30%

MMPRT repair (%WBL=50%)





a Statistical significance ($p<0.05$) in the intact versus MMPRT conditions.
b Statistical significance ($p<0.05$) in the MMPRT versus repair condition.

Comparison of CA among the three conditions (mm^2)

%WBL (%)	30	40	**50**	55	60	65	70
Intact (mm^2)	532	507	**463**	431	398	355	295
MMPRT (mm^2)	350	346	**324** ↓	315	298	272	233
Repair (mm^2)	486	468	**447** ↑	419	371	308	250

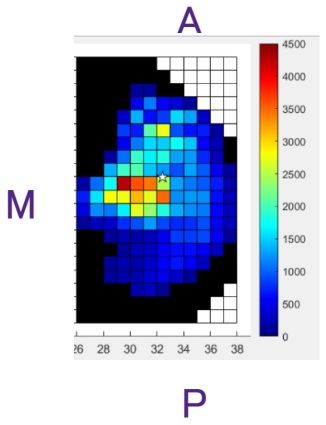
CA, contact area

CA decrease by 30% after MMPRT and approaches to intact after MMPRT repair

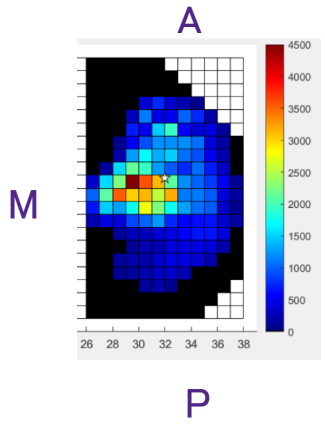
Result: contact pressure and contact area in the lateral compartment

Lateral

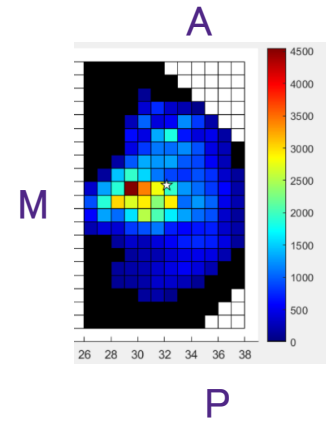
Intact (%WBL=50%)

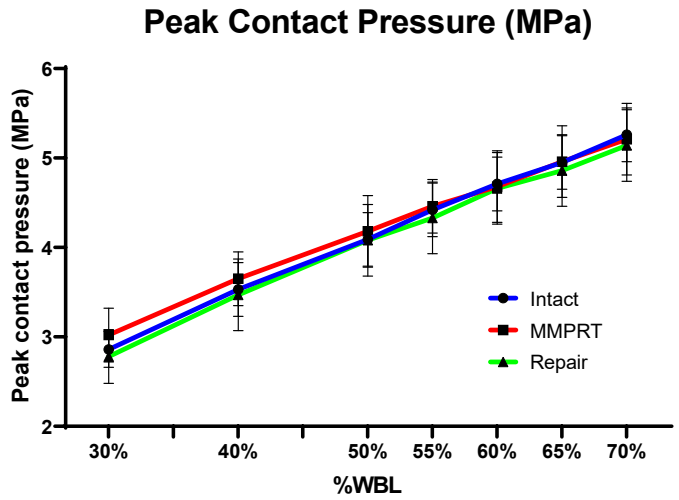


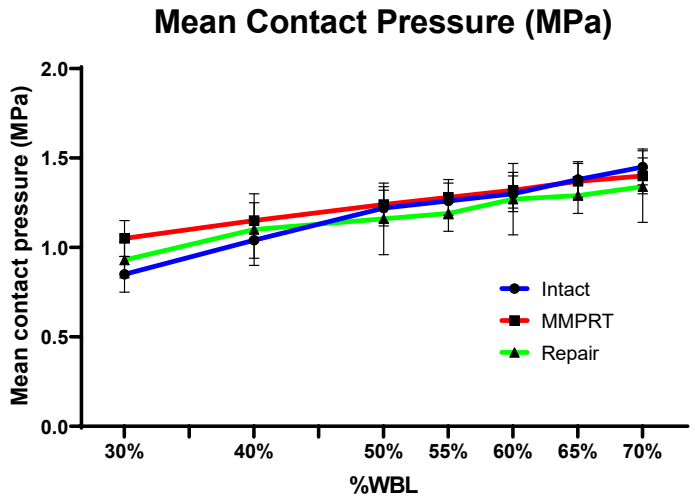
MMPRT (%WBL=50%)

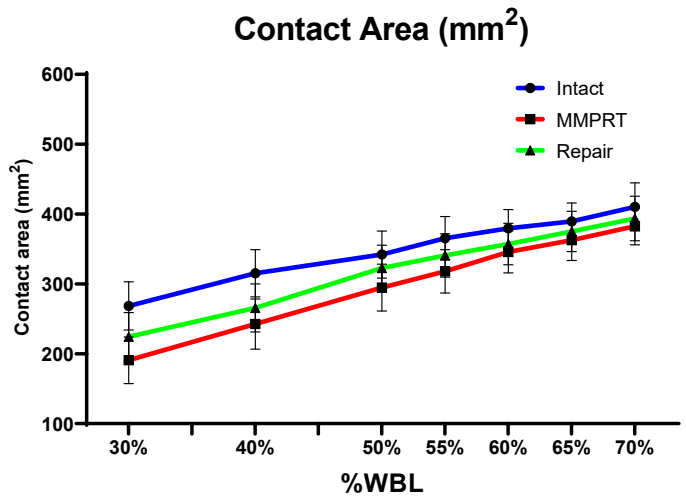


MMPRT repair (%WBL=50%)









PCP, MCP, and CA increase with valgus alignment, with no significant differences between conditions.

Discussion: optimal alignment for MMPRT

Past clinical studies

A 62.5% WBL target for MMPRT showed short-term clinical and radiographic success, but its biomechanical validation is lacking.

Surgical Technique

A single-surgeon performed all surgical procedures. The target mechanical axis was the weight-bearing line passing through 62.5% of the width of the tibial plateau, correspond-

62.5 %

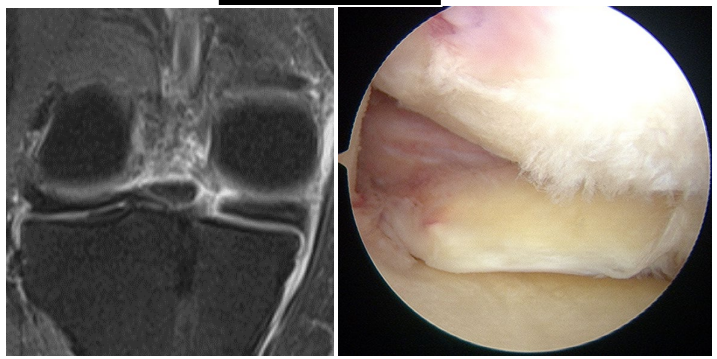
Choi et al. KSSTA 2023
Lee et al. J Knee Surg 2022
Lee et al. Arthroscopy 2020

Our study suggests that:

- ✔ 60–65% WBL for unrepaired MMPRT
- ✔ 50–55% WBL for repaired MMPRT

Individualized target alignment based on the meniscal status

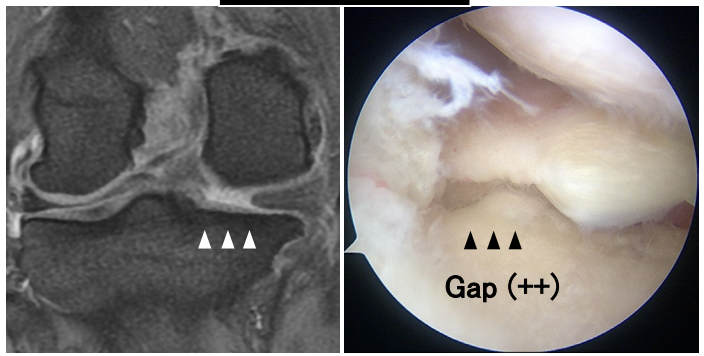
Acute case



MMPRT is repairable, and successful repair is anticipated

50–55 %

Chronic case



MMPRT is not repairable, or re-rupture is anticipated.

60–65 %

Conclusion

PCP and MCP at neutral alignment in the intact condition were comparable to those at

60–65% WBL for unrepaired MMPRT

50–55% WBL for repaired MMPRT

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