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Change of equivalent stress on medial meniscus posterior root after high tibial osteotomy: Analysis using finite element method using MRI images

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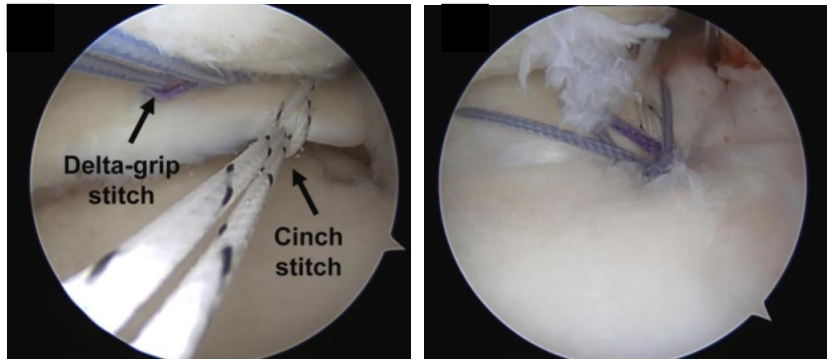
Disclosure Information

- Nothing to disclosure

Open wedge high tibial osteotomy
（OWHTO）

- Reduced contact pressure in medial compartment of the knee[1)]
- Combined with medial meniscus posterior root (MMPR) repair[2)]



Stress changes to the meniscus before and after OWHTO are not clear.

Purpose

We created a 3D finite element model (3D-FEM) from MRI images of a patient who underwent OWHTO, and examined the change in Von-Mises stress (VMS) applied to the regions of meniscus before and after surgery.

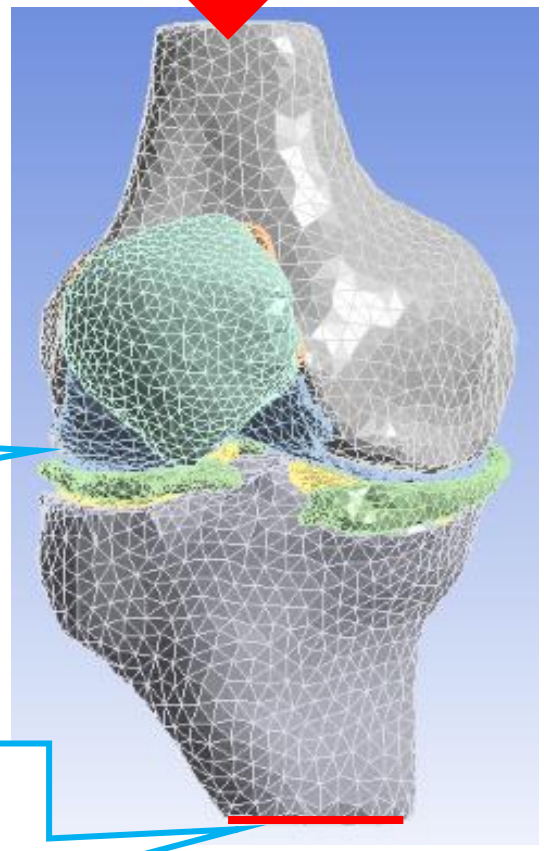
Subject

- 60 years old Male who underwent OWHTO
  （BMI 27.4 kg/m^2）

- MRI: ① Pre OWHTO
  ② Post OWHTO
  （One year after Op.）

Axial load

1,150 N



Walking load value

Fixed between each structure

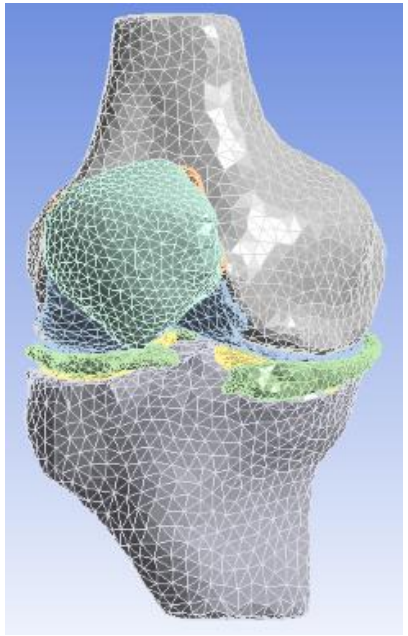
Constrained

Pena E, et al. Clinical Biomechanics. 2005

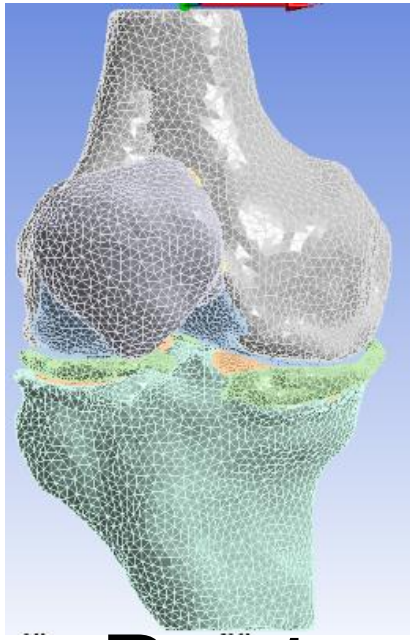
3D-FEM

- 3D images were extracted the MRI images using SYNAPSE VINCENT（Fujifilm）
- Mesh model was created using HyperMesh (Altair)
  - ✓ Femur, Tibia, Patella、Meniscus

	Young's moduli （MPa）	Poisson's ratio[3)]
Cortical bone	30,000	0.2
Cancellous bone	2,000	0.3
Cartilage	15	0.4
Meniscus	10	0.4



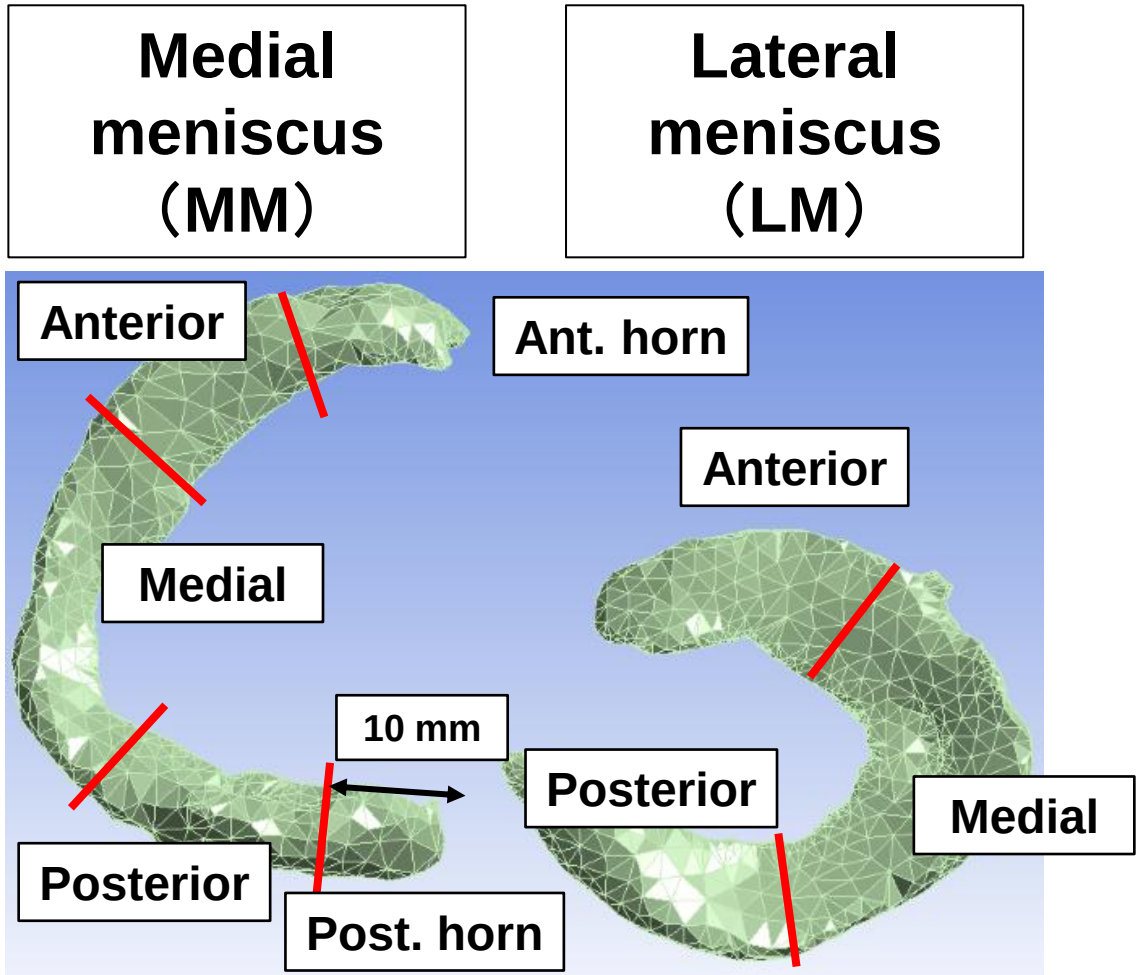
Pre
OWHTO



Post
OWHTO

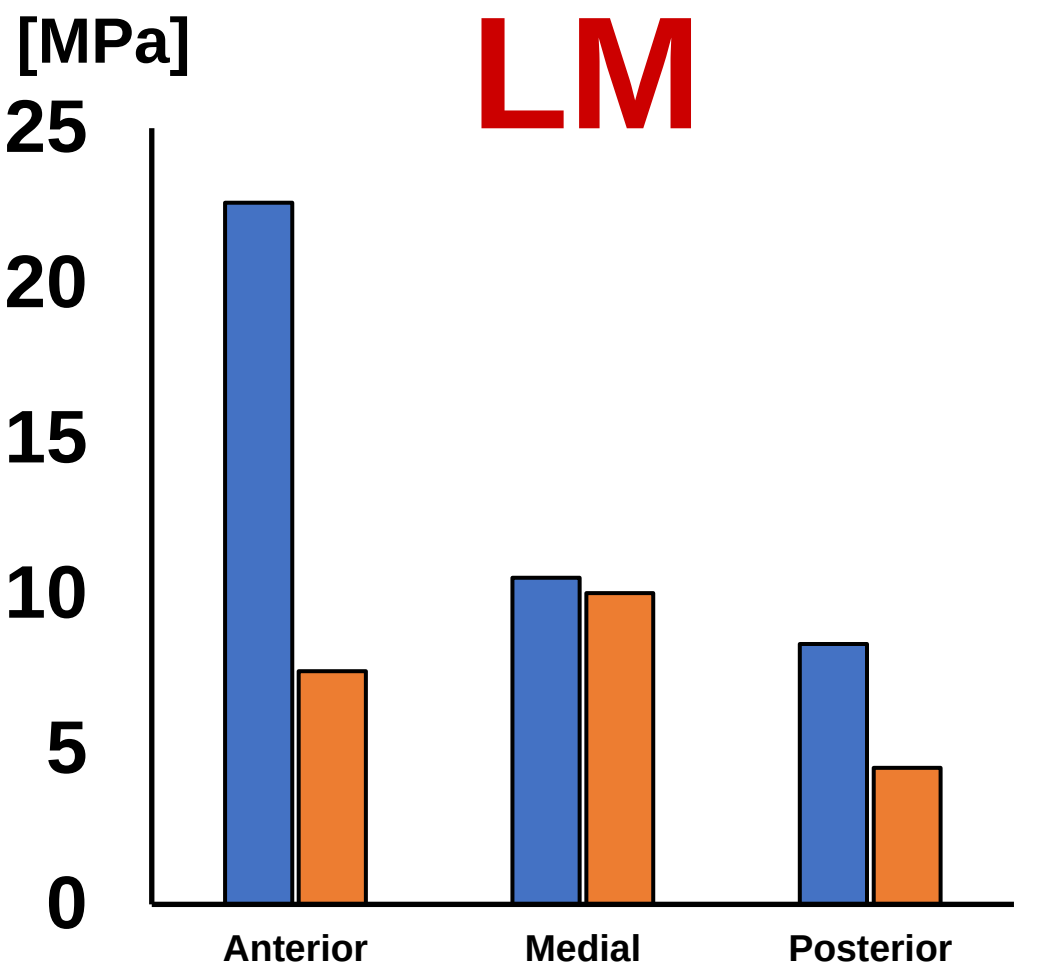
VMS of the meniscus

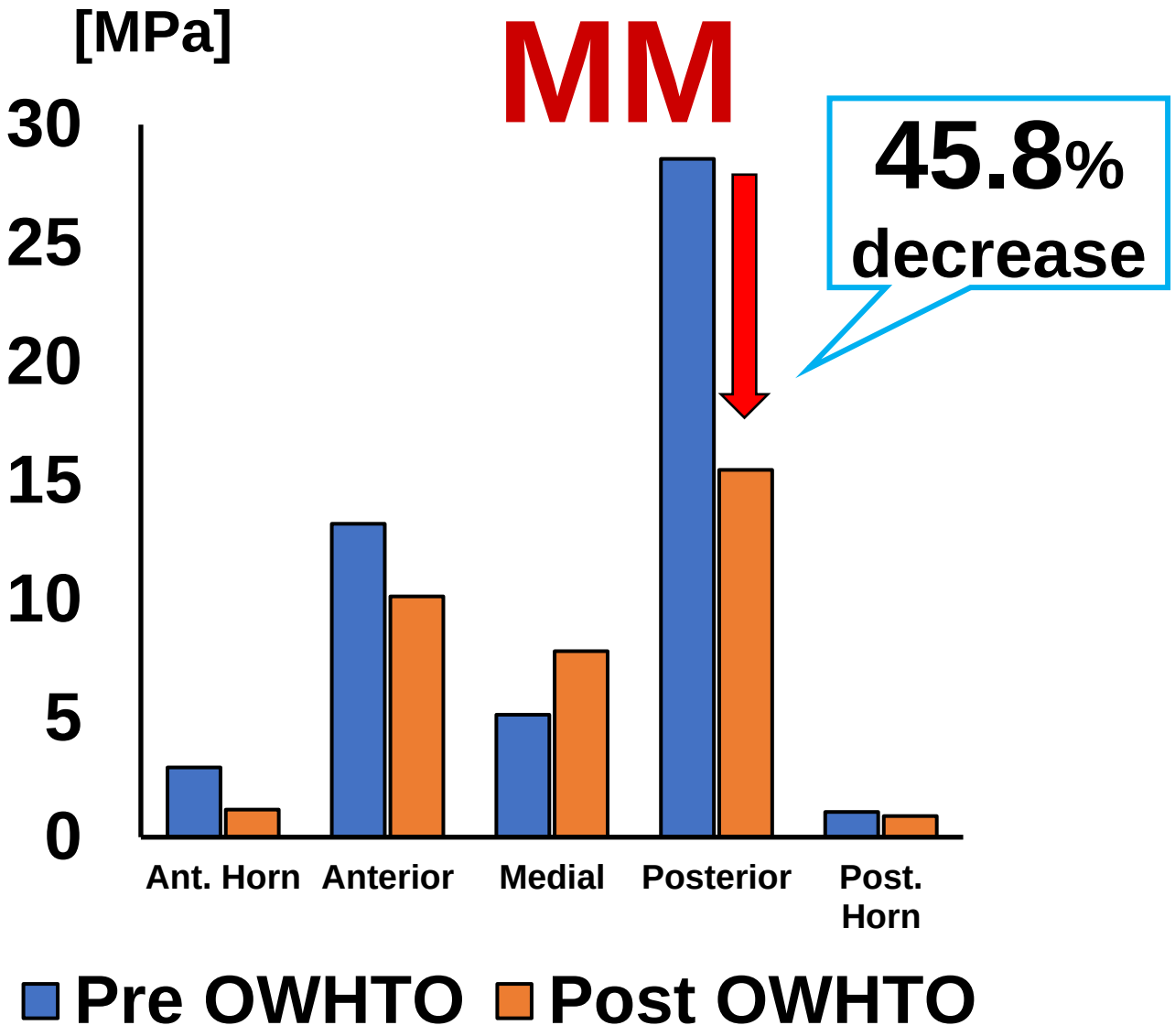
- **Stress analysis:** Ansys (2021,R2)
- Compartmentalized meniscus
- The max. VMS of each compartment was compared before and after OWHTO



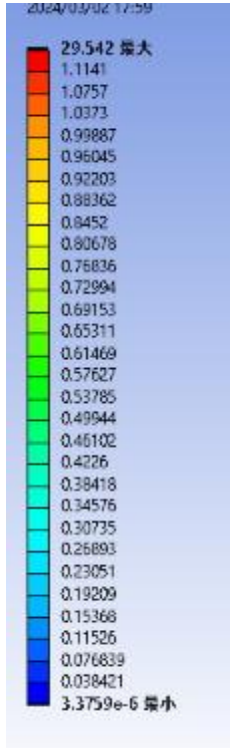
Moatshe G, et al. Acta Orthop. 2016

Max. VMS

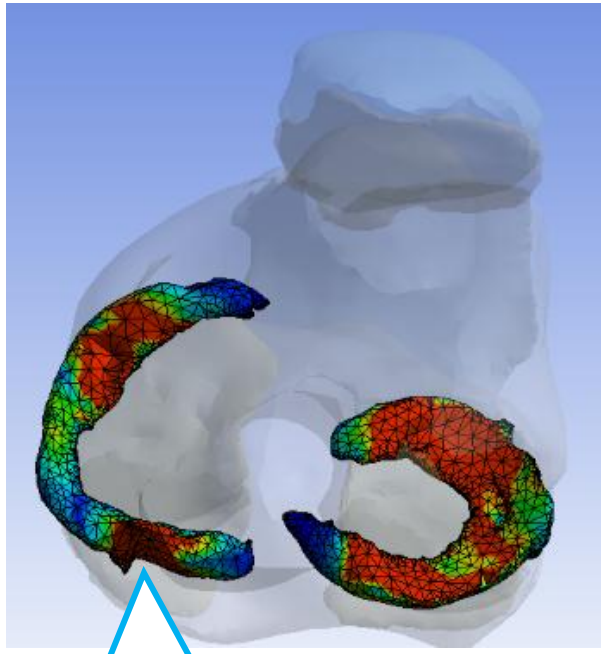

[MPa]
LM
25
20
15
10
5
0
Anterior
Medial
Posterior
Pre OWHTO
Post OWHTO


[MPa]
MM
30
25
20
15
10
5
0
45.8%
decrease
Ant. Horn
Anterior
Medial
Posterior
Post. Horn
Pre OWHTO
Post OWHTO

Max. VMS of meniscus

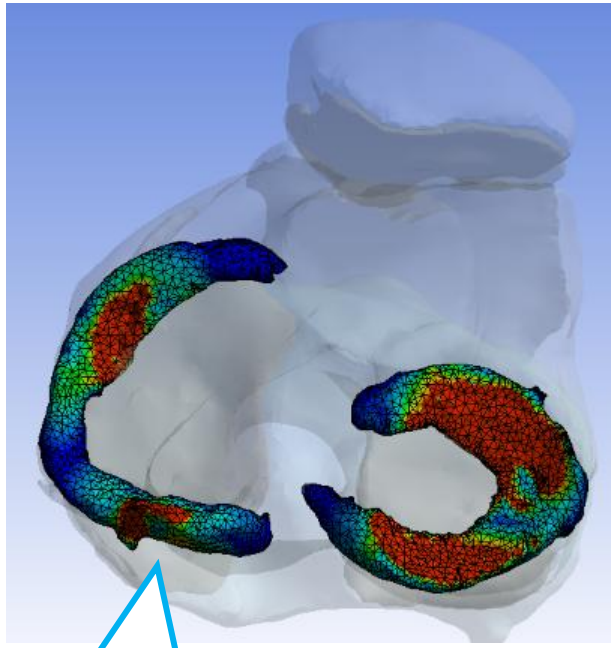


Pre OWHTO

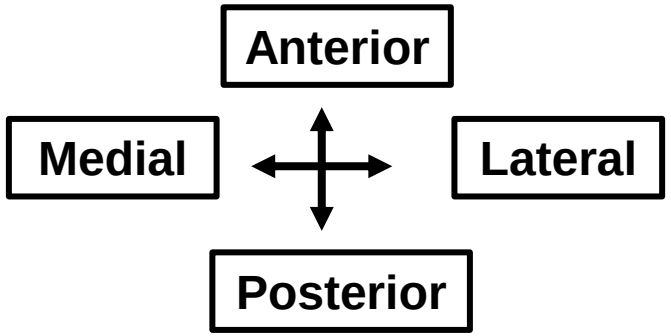


28.6 MPa

Post OWHTO



15.5 MPa



MM stress change after OWHTO

- Decreased contact pressure in medial compartment in cadaver study.[4)]

- In the FEA of OWHTO model with varying correction angle, as the opening significantly increased, the max. VMS of the LM increased and the max. VMS of the MM decreased.[5)]

- This study：FEA showed a decreased in max. VMS in the posterior segment of the MM.

OWHTO reduces stress in the MM posterior segment

Limitations

- The load axis was not changed before and after OWHTO.
- Changes in the condition of cartilage and meniscus in the postoperative course.
- The model was not included extra-articular soft tissue.

Conclusion

Analysis using 3D-FEM created from MRI images demonstrated that the max. VMS of the MM was reduced after OWHTO.

References

1) Agneskirchner JD, et al. Arch Orthop Trauma Surg. 2004
2) Ishibashi Y, et al. Arthrosc Tech. 2024
3) Keyak JH, et al. J Biomech. 1998
4) Mina C, et al. AJSM. 2008
5) Chen L, et al. Math Biosci Eng. 2024