A FINITE ELEMENT ANALYSYS OF HINGE POSITION IN MEDIAL CLOSING WEDGE DISTAL FEMORAL OSTEOTOMY TO PREVENT HINGE FRACTURE

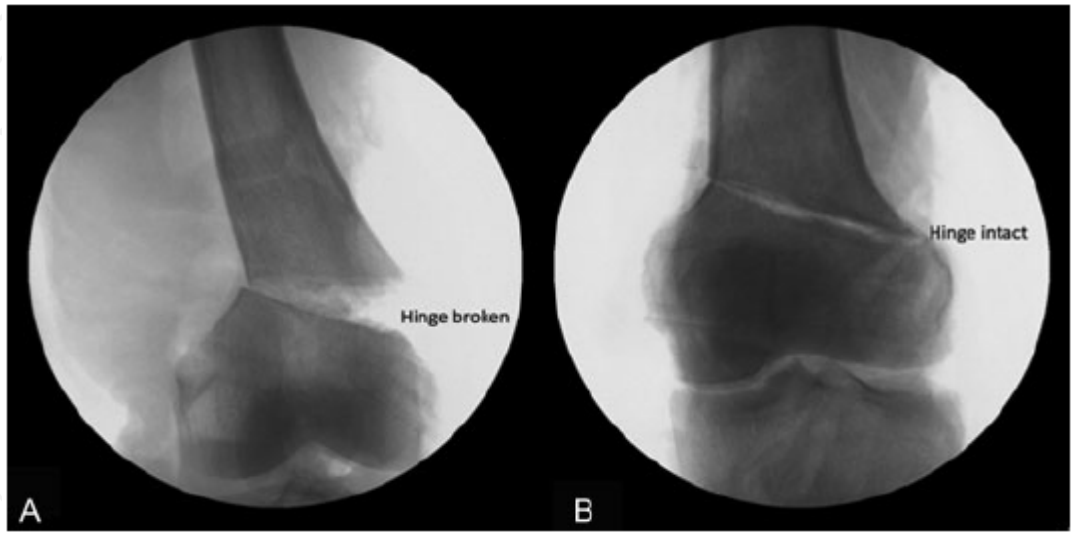
1. Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Japan
2. Department of Mechanical Engineering, Kobe University Graduate School of Engineering, Japan

Atsuki Tanaka[1], Takehiko Matsushita[1], Tatsuya Nakatsuji[2], Yosuke Katsui[2], Kanto Nagai[1], Toshiji Mukai[2], Ryosuke Kuroda[1]

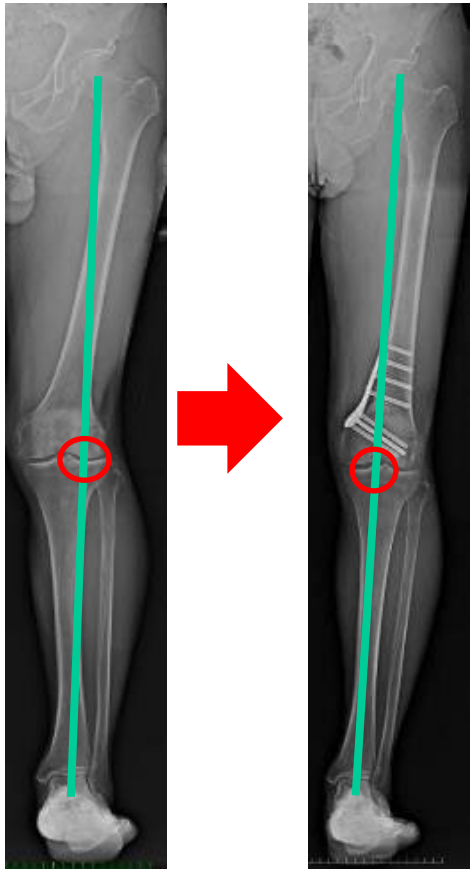
Medial closed wedge distal femoral osteotomy (MCWDFO)

✓ Effective treatment for valgus knee osteoarthritis

- **Complication**
  - ✓ Hinge fracture
- **Cause**
  - ✓ Wedge angle
  - ✓ Hinge position



1) Nha, KW., et al. J Knee Surg. 2019.

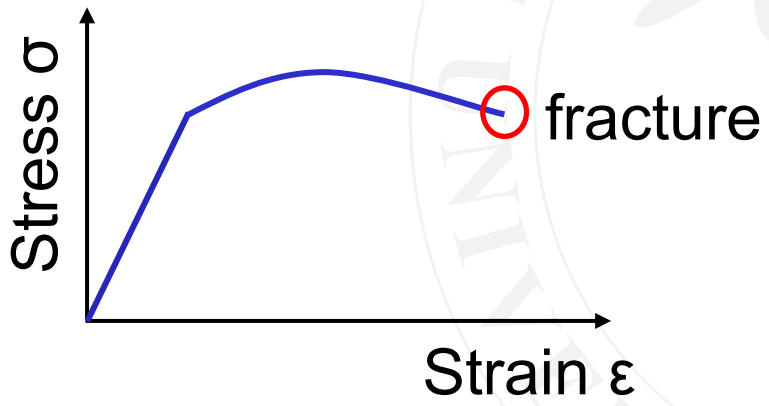


Biomechanical verification have not been adequately conducted

Conflict of interest
No potential conflict of interest relevant to this presentation was reported

Purpose

To identify optimal hinge position using finite element (FE) models with biomechanical tests



Strain around hinge area↑

↓

Risk of hinge fracture↑

2) Li, S., et al. J Mech Behav Biomed Mater. 2013.

Hypothesis

→ Smaller maximum principal strain reduces the risk of hinge fracture

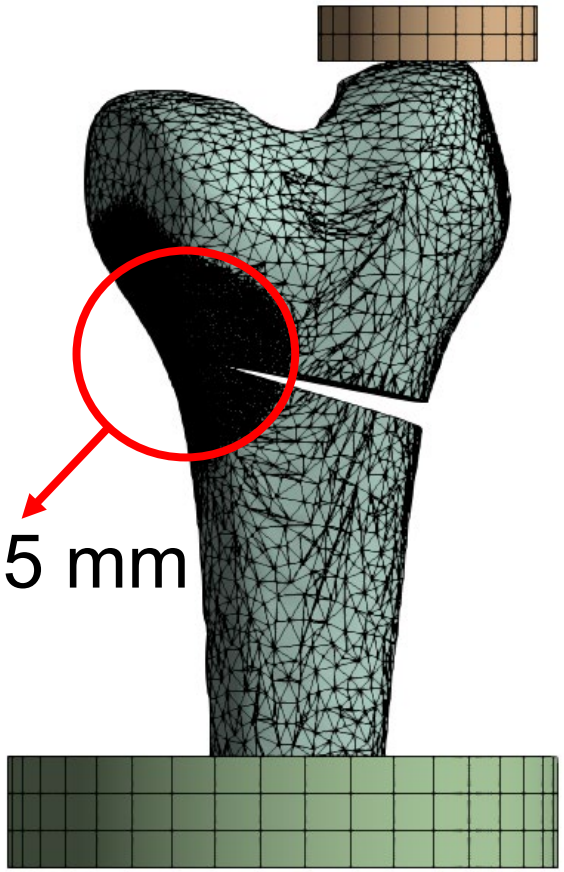
Modeling and Analysis

Composite bone (Sawbone)

CT scan for composite femur bone

Cortical and trabecular bone were distinguished

Osteotomy CAD model

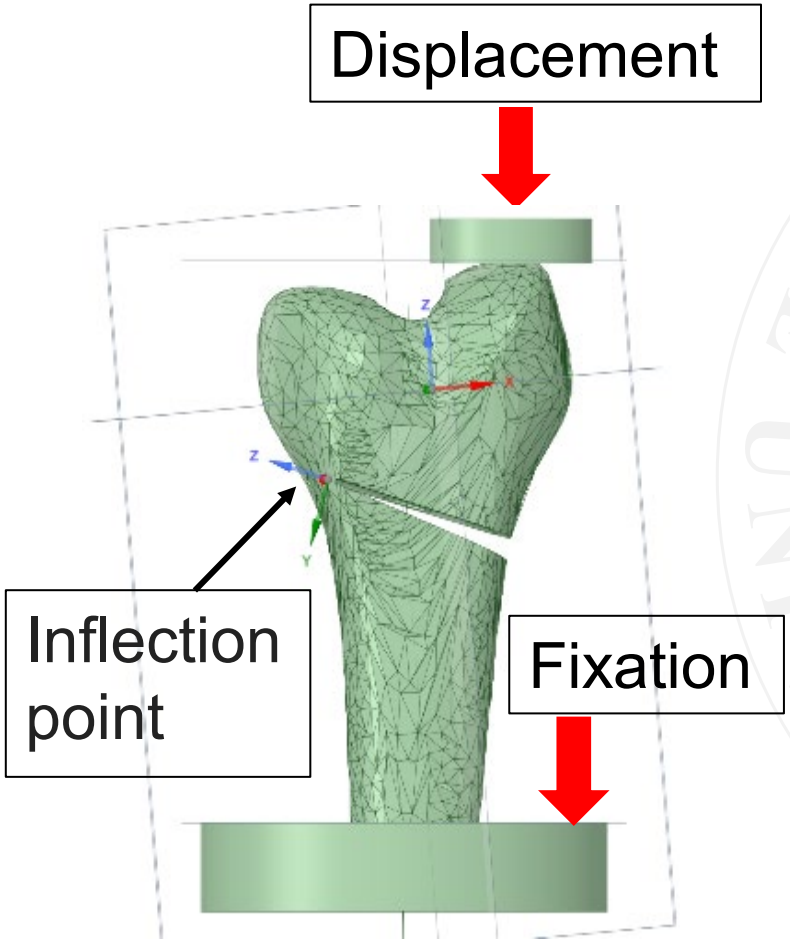


Osteotomy CAD model

- Analysis: Linear elastic
  - Software：ANSYS mechanical
- Young's modulus
  - Cortical bone: 17 Gpa
  - Trabecular bone: 155 Mpa
- Poisson's ratio: 0.30
- Mesh: Tetrahedral mesh
- Elements: 4.3×10^5
- Nodes: 6.5×10^5

3) Tucker, S.M., et al. J Orthop Res. 2019.

Modeling and Analysis



■ Condition 1

- **Wedge angle**

A) 5 degrees
B) 7.5 degrees
C) 10 degrees

- **Hinge position:** Inflection point

■ Condition 2

- **Wedge angle:** 5 degrees
- **Hinge position from the inflection point**

D) 10 mm proximal
E) Inflection point
F) 5 mm distal

■ **Distance between hinge and the lateral cortex**: 5 mm

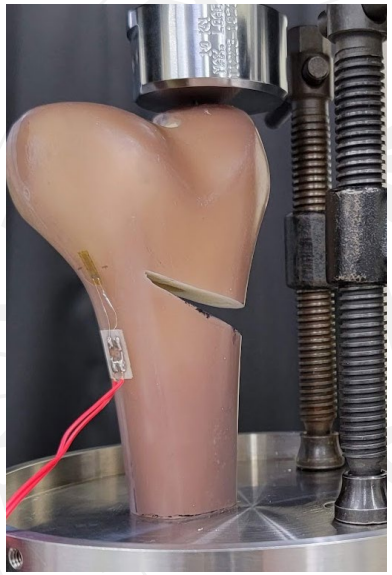
■ **Osteotomy**: Single plane

The maximum principal strains at the hinge areas were compared among the models

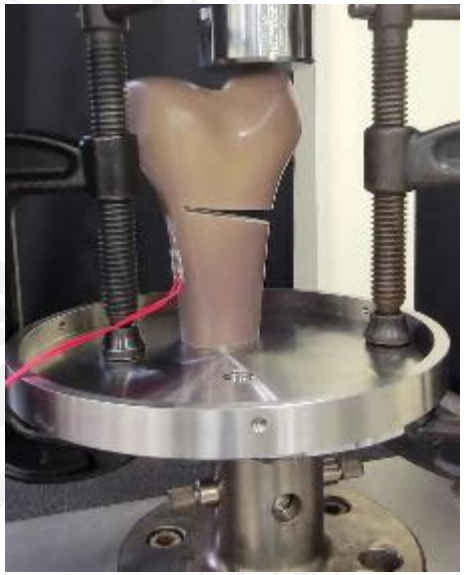
Mechanical test

- The same models as FE models (Model A(E), C, D, and F)

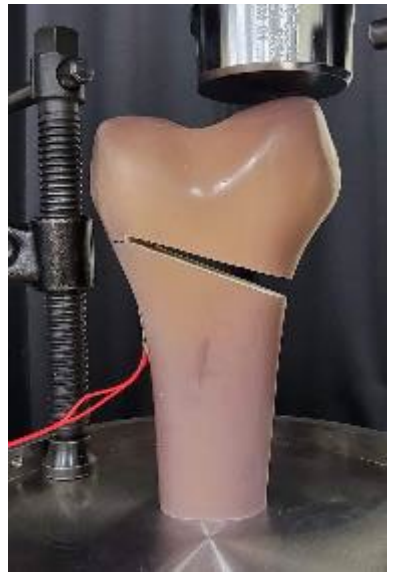
Model A (E)
Inflection point
5 degrees



Model C
Inflection point
10 degrees



Model D
10 mm proximal
to the inflection point
5 degrees

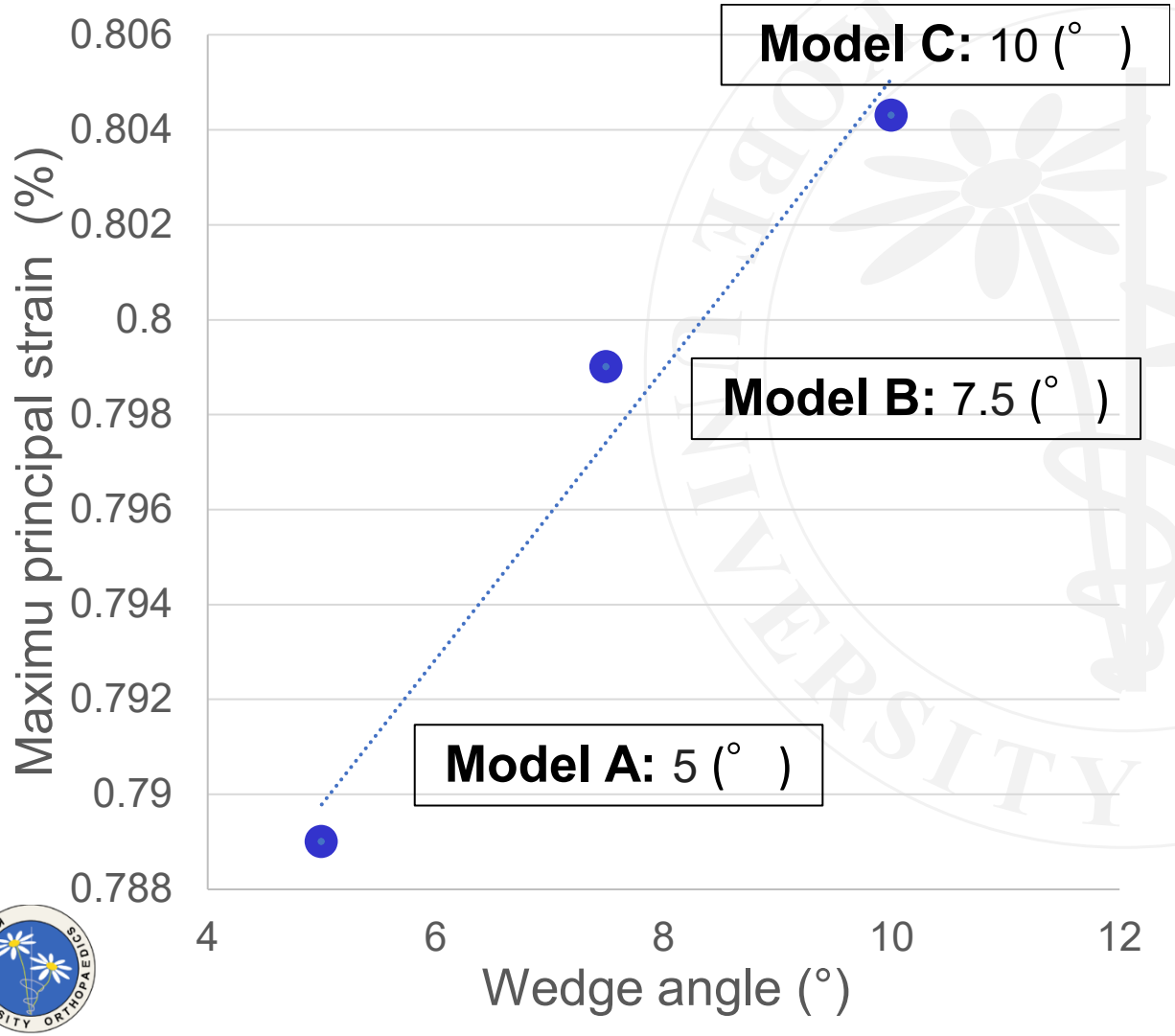


Model F
5 mm distal
to the inflection point
5 degrees

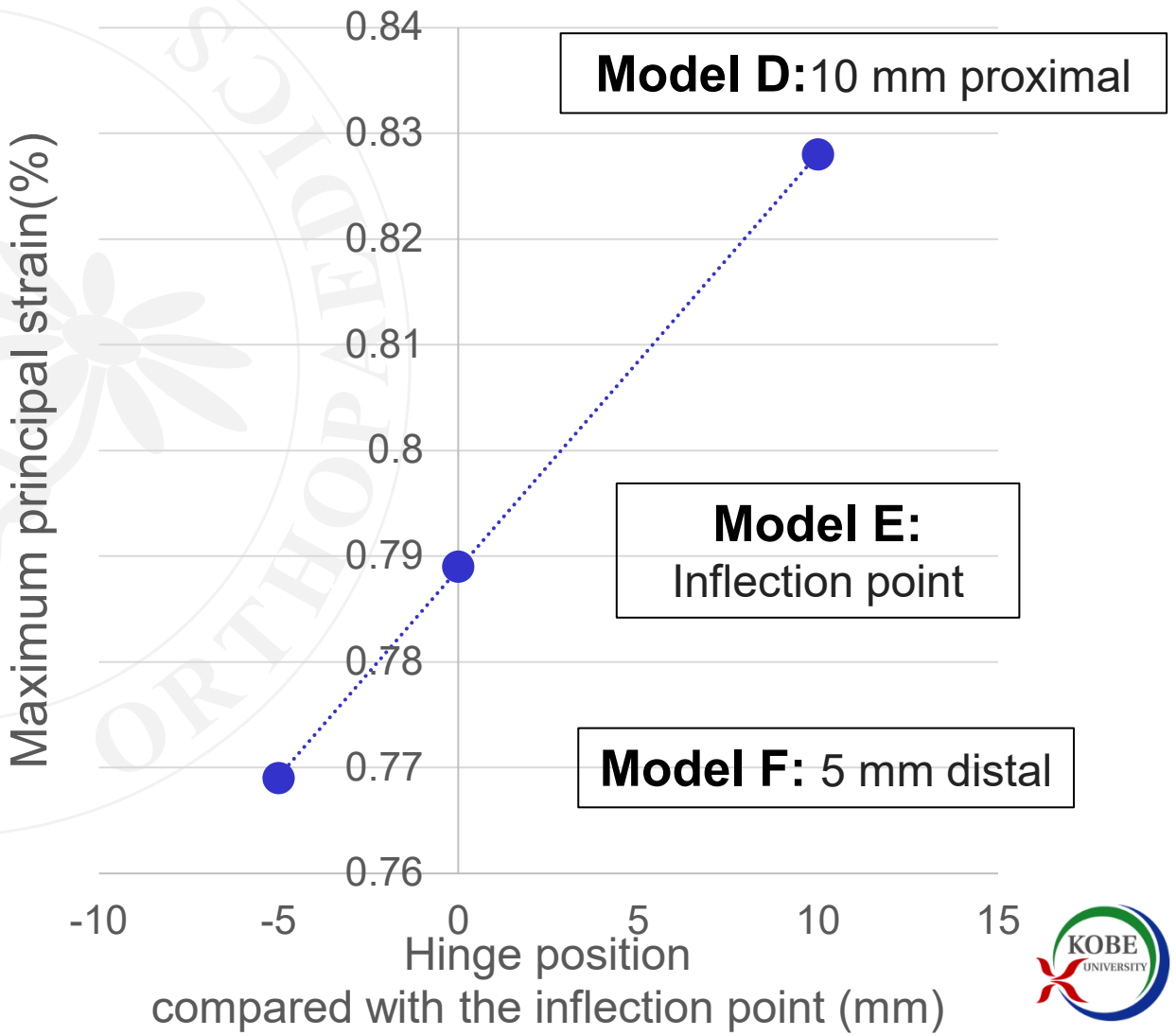
➡ **Examine hinge fracture during closure**

Result

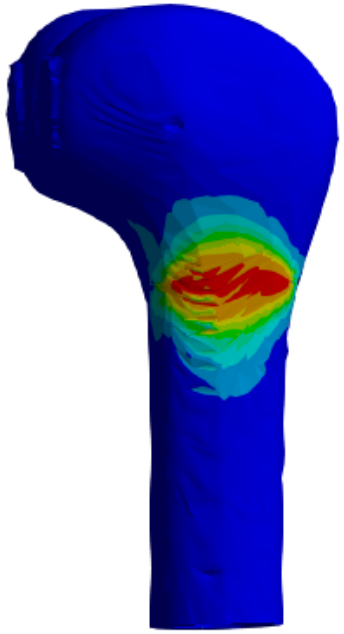
■ Condition 1



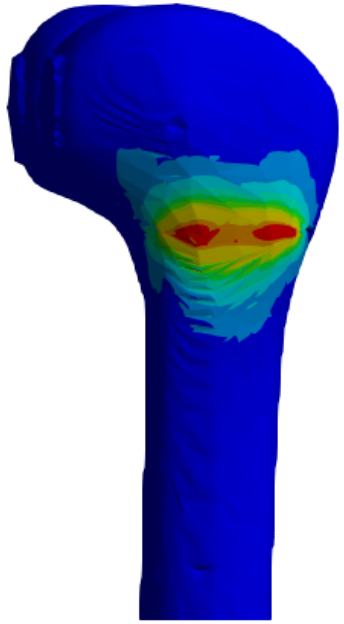
■ Condition 2



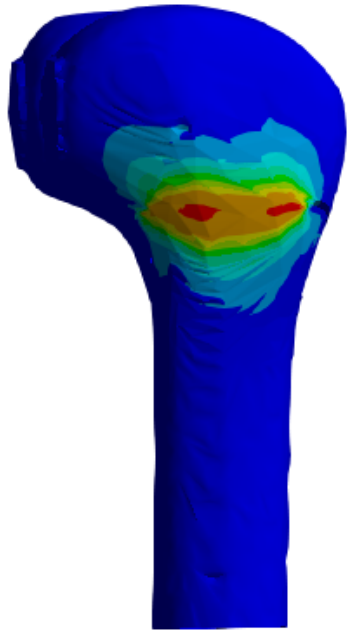
Distribution of maximum principal strain



Maximum principal strain :
0.828%
Model D
10 mm proximal to the inflection point



Maximum principal strain :
0.789%
Model E
the inflection point



Maximum principal strain :
0.769%
Model F
5 mm distal to the inflection point

Maximum area : Proximal area of hinge

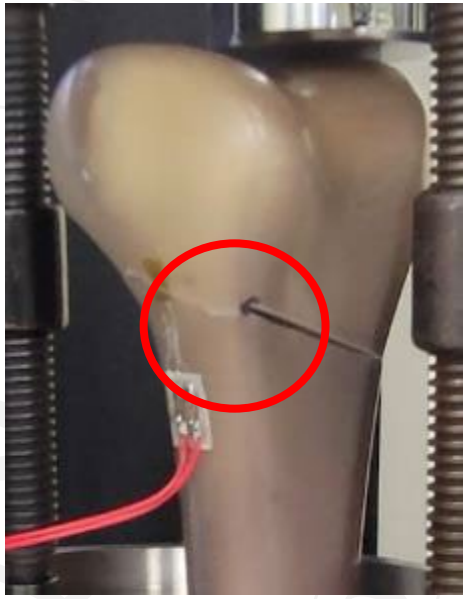
Mechanical test

Model C

the inflection point
10 degrees

Model D

10 mm proximal
to the inflection point
5 degrees



Model A(E)

the inflection point
5 degrees

Model F

5 mm distal
to the inflection point
5 degrees

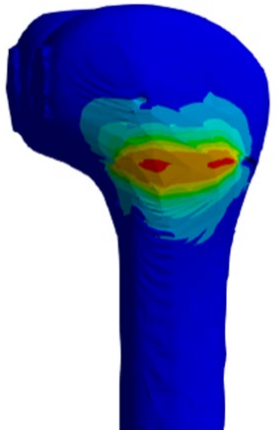
Hinge fractures occurred in **Model A, C and D**
No hinge fracture occurred in **Model F**
(5 mm distal to the inflection point)

Discussion

- The maximum principal strain increased when the wedge angle was larger.
- Model F: 5 mm distal to the inflection point

  FE Analysis: Minimum model of maximum principal strain

  Mechanical test: No hinge fracture



- Hinge position should be in the lateral condylar region

1) Nha, KW., et al. J Knee Surg. 2019.

➡ Consistent with our results

Discussion

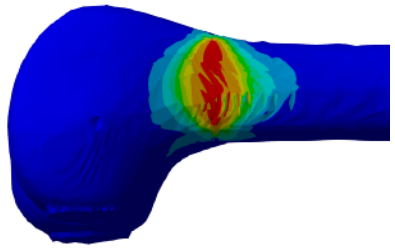
- Maximum value of maximum principal strain : Proximal area of hinge
- Mechanical test:

  Hinge fractures occurred in the proximal area of the hinge

- Condylar region may have more plasticity than supracondylar region

4) Kim, TW., et al., Am J Sports Med. 2019.

	Condyle	Supracondylar
Strain	Smaller	Larger
Hardness	Softer	Harder



- The hinge proximal should be located in the condylar region

Conclusion

The hinge position distal to the inflection point would be a favorable position in MCWDFO

References

1) Nha KW, Chang YS, Shon OJ, et al. Where is the Target Point to Prevent Cortical Hinge Fracture in Medial Closing-Wedge Distal Femoral Varus Osteotomy?. J Knee Surg. 2019;32:274-279.

2) Li S, Demirci E, Silberschmidt VV. Variability and anisotropy of mechanical behavior of cortical bone in tension and compression.
J Mech Behav Biomed Mater. 2013;21:109-120.

3) Tucker SM, Wee H, Fox E, Reid JS, Lewis GS. Parametric Finite Element Analysis of Intramedullary Nail Fixation of Proximal Femur Fractures.
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4) Kim TW, Lee MC, Cho JH, Kim JS, Lee YS. The Ideal Location of the Lateral Hinge in Medial Closing Wedge Osteotomy of the Distal Femur: Analysis of Soft Tissue Coverage and Bone Density. Am J Sports Med. 2019;47:2945-2951.