

Virtual triple bundle ACL graft on 3-D CT via femoral tunnels placed behind the Resident's ridge based on the bony landmark strategy shows equivalent orientation to the native ACL on MRI

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Faculty Disclosure Information

Nothing to disclose

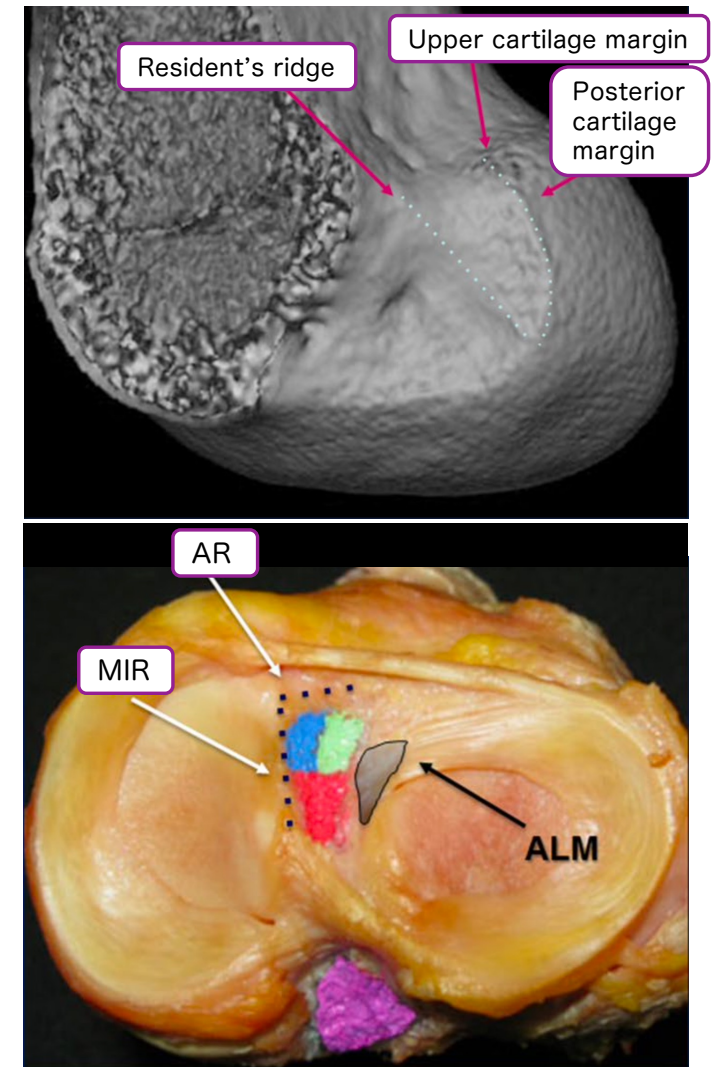
Background

The normal anterior cruciate ligament (N-ACL) consists of three fiber bundles:

- Anteromedial bundle medial part (AMM)
- Anteromedial bundle lateral part (AML)
- Posterolateral bundle (PL)

We have been adopting the bony landmark strategy (BLS) to delineate ACL attachment areas in the anatomical triple-bundle ACL reconstruction^[1].

It is ideal to position the grafts to mimic the N-ACL; however, there is no consensus on the optimal femoral tunnel position.



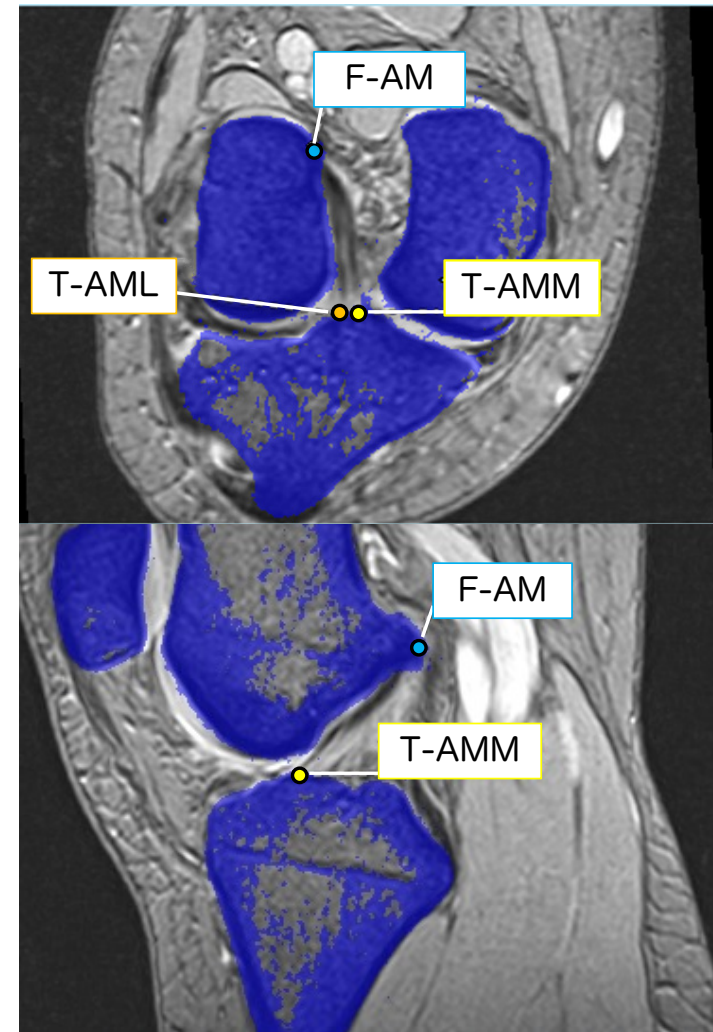
AR: Anterior ridge
MIR: Medial intercondylar ridge
ALM: Anterior horn of the lateral meniscus

Shino et al. J Orthop Sci, 2015

CT-MR Image Matching

A technique for matching bone images of CT and those on MRI has become available in recent years^[2].

This technique enables the projection of a virtual ACL graft (VACLG) on a CT model onto MRI.



CT bone image (blue shadow)
on MRI (black and white)

Purpose

To compare the orientation of

- N-ACL on MRI
- VACLG* on 3-D CT

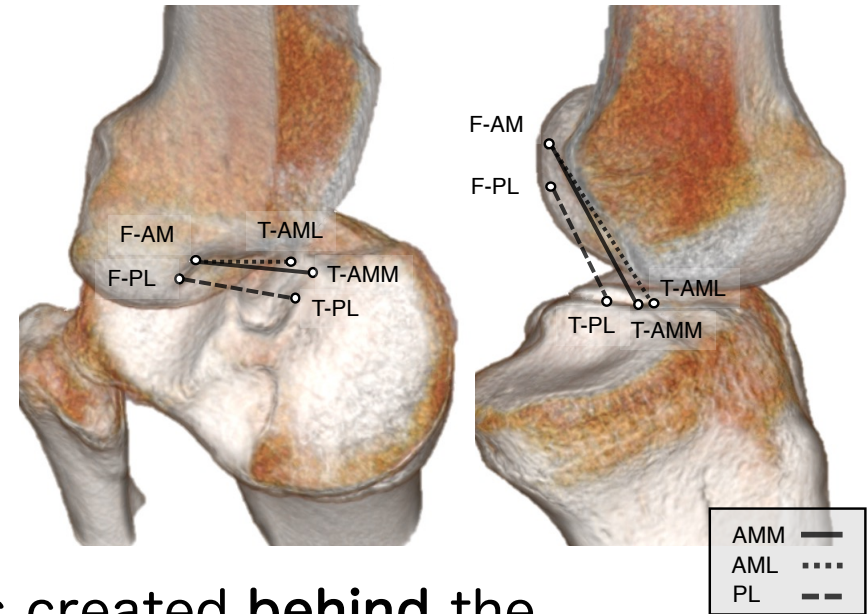
in the same knee.

Two VACLGs* were created:

- BR-VACLG: the femoral tunnels created **behind** the Resident's ridge (RR)
- OR-VACLG: the femoral tunnels created **on** the RR

Our hypothesis was that

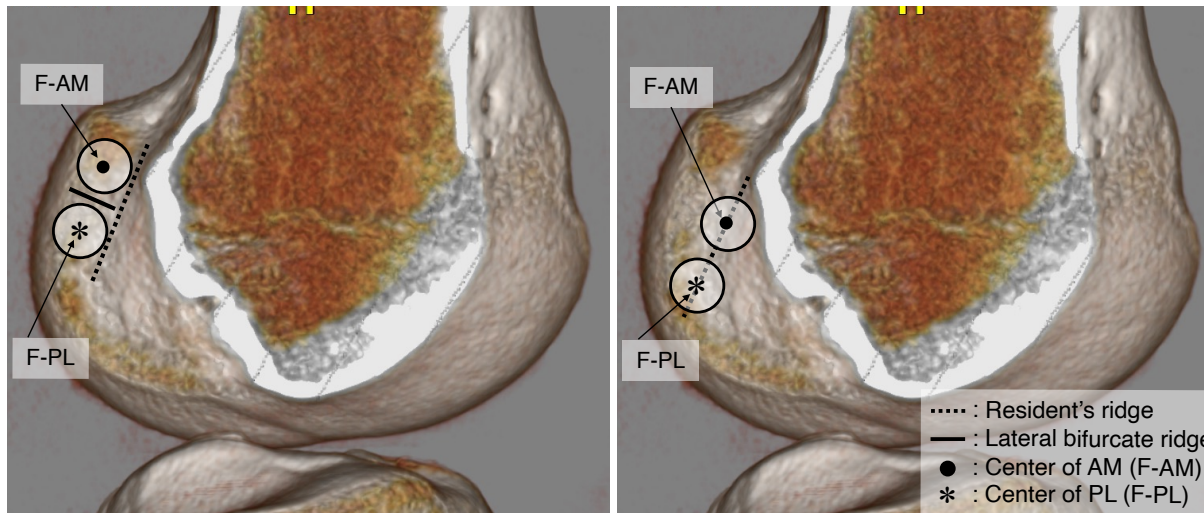
BR-VACLG on the 3-D CT showed the closer orientation to N-ACL on MRI.



Methods

- 3-D CT and MRI were obtained in 14 normal left knees in full extension.
(7 females and 7 males, mean age of 27.8 ± 4.6 years)
- Two types of VACL with different femoral tunnel positions were compared.

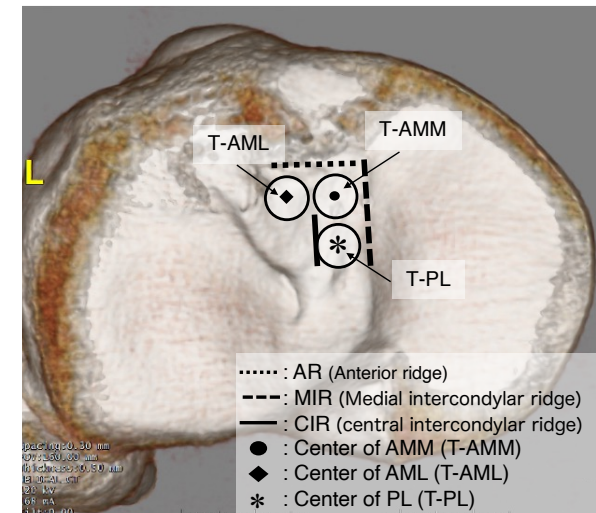
The femoral attachment site
(Two $\varnothing$ 7-mm circles)



BR-VACL

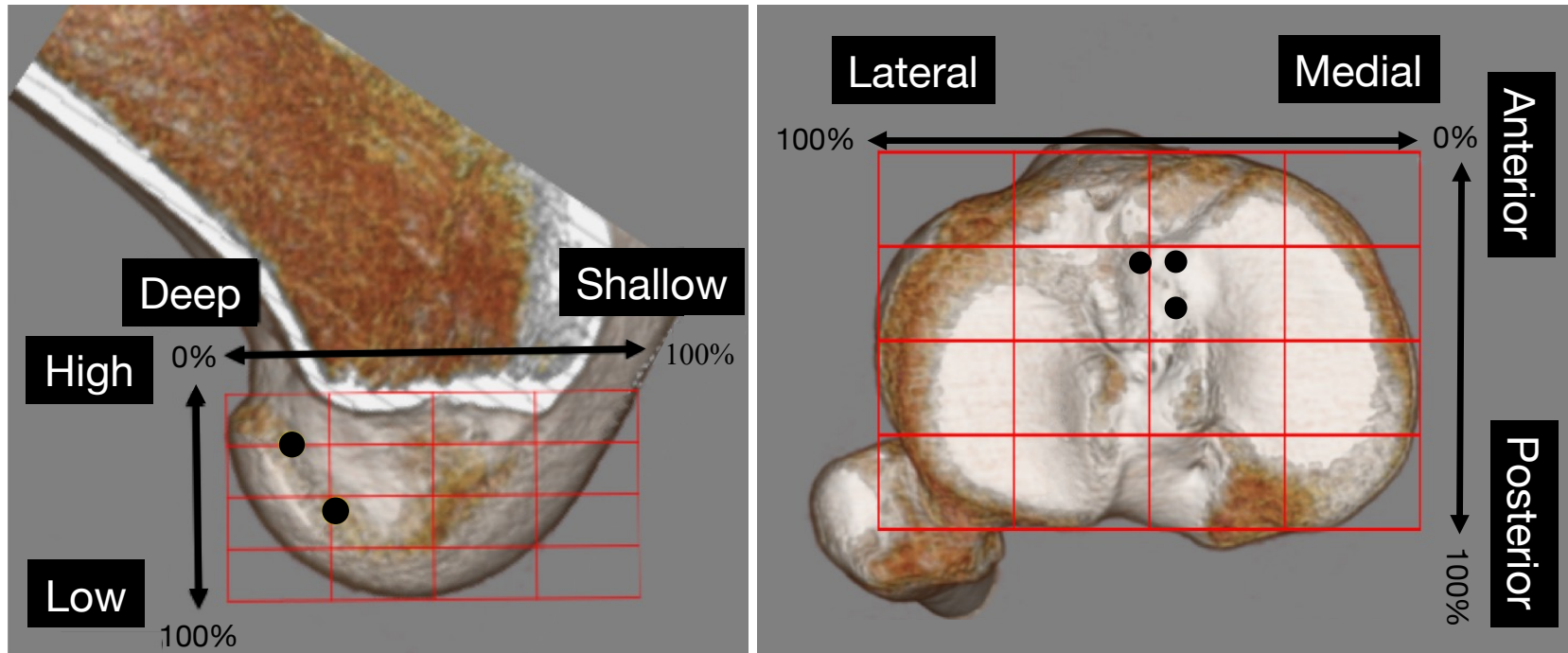
OR-VACL

The tibial attachment site
(Three $\varnothing$ 5-mm circles)



Measurements

1. ACL attachment position of each bundle on CT



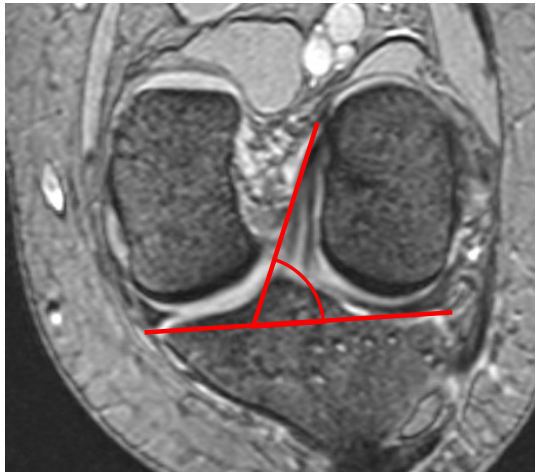
The location of the attachment position of each bundle of BR-VACL and OR-VACL was evaluated using the quadrant method on 3-D CT images^[3, 4].

2. Comparison of orientation between the N-ACL and the VACLGs

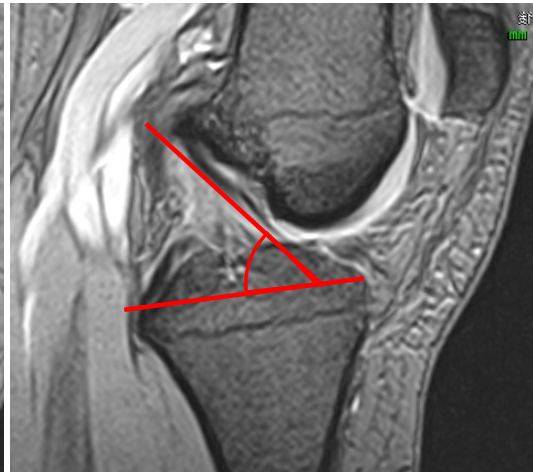
ACL-tibial plateau angle (ACL-TP angle)

was measured in oblique-coronal and sagittal images based on the method reported by Take et al^[5].

NACL (AMM)

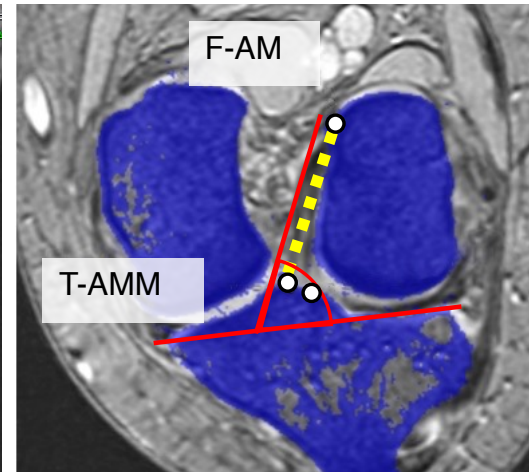


Oblique-coronal plane

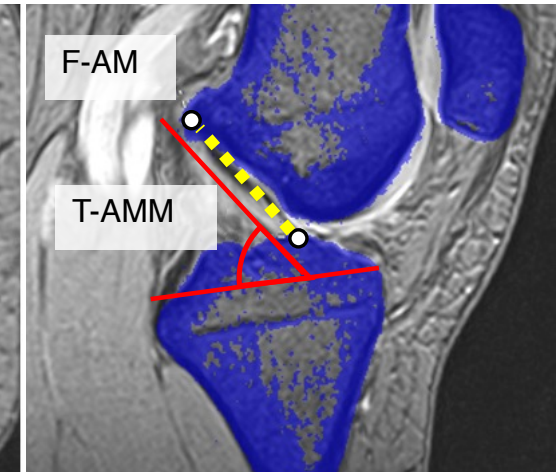


Oblique-sagittal plane

VACLG (AMM)



Oblique-coronal plane



Oblique-sagittal plane

Results

1. The location of BR-VACL and OR-VACL by the Quadrant Method

Femoral Tunnel

	Deep-Shallow			High-Low		
	BR-VACLG	OR-VACLG	<i>P</i>	BR-VACLG	OR-VACLG	<i>P</i>
AM	13.6 ± 2.5%	24.9 ± 2.8%	0.012	22.1 ± 9.0%	30.5 ± 3.6%	0.036
PL	25.3 ± 3.1%	37.2 ± 4.2%	0.012	52.0 ± 7.0%	59.3 ± 3.9%	0.018

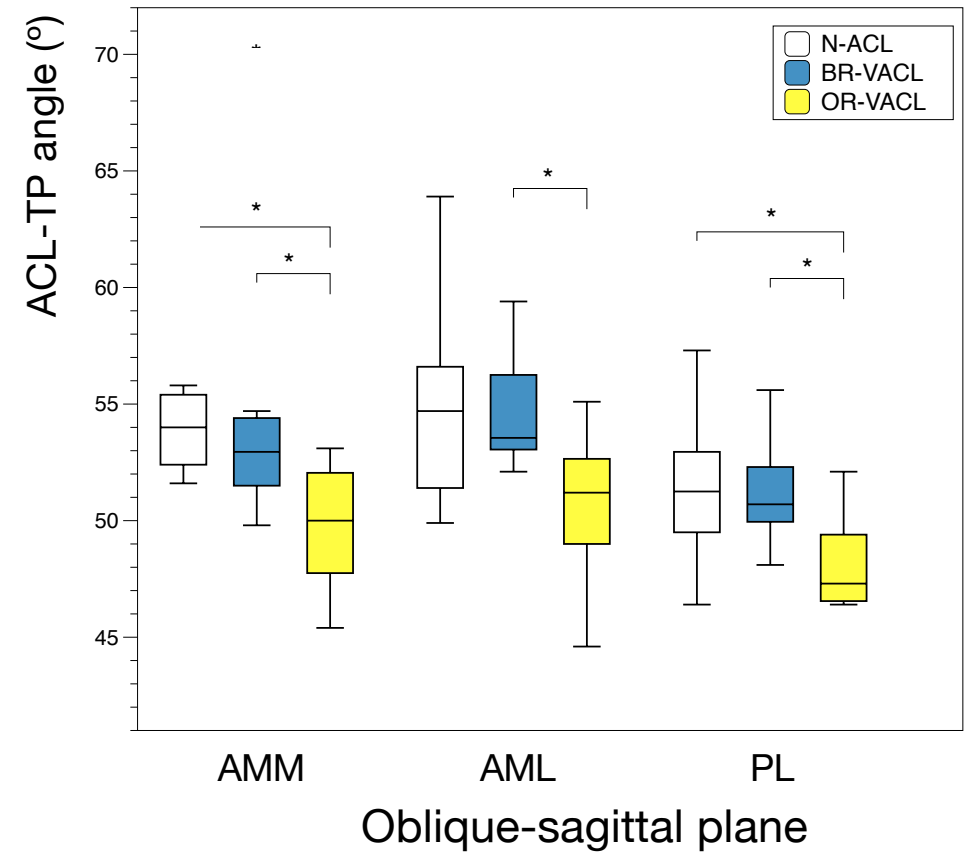
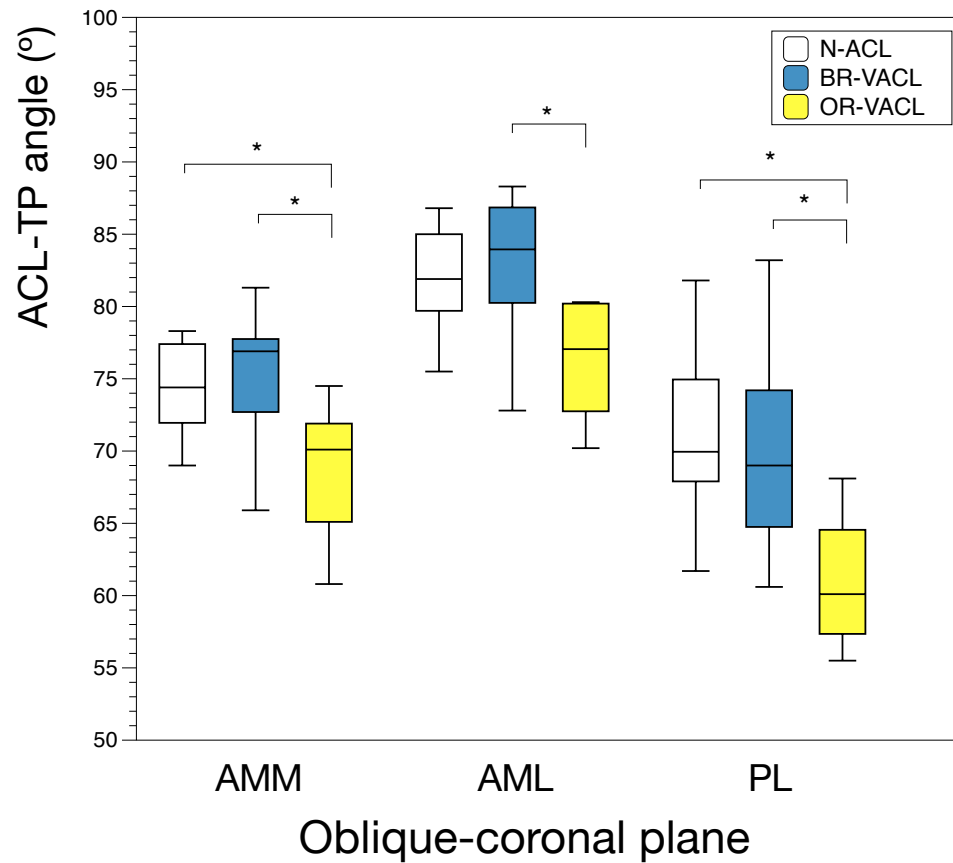
Wilcoxon signed-rank test ($\alpha = 0.05$)

Tibial Tunnel

	Mediolateral	Anteroposterior
AMM	44.0 ± 1.5%	23.4 ± 2.9%
AML	50.0 ± 1.9%	28.0 ± 2.9%
PL	43.5 ± 1.6%	39.2 ± 3.0%

The femoral tunnels of the OR-VACLG were statistically-significantly shallower and lower compared to those of the BR-VACLG in both AM and PL.

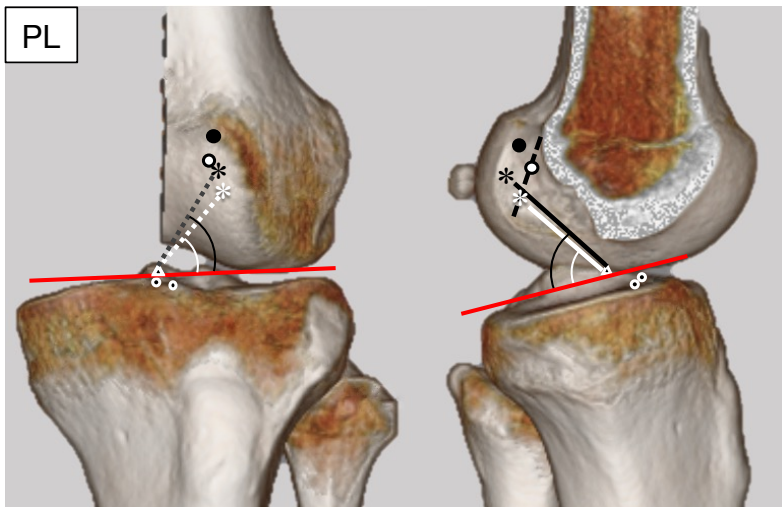
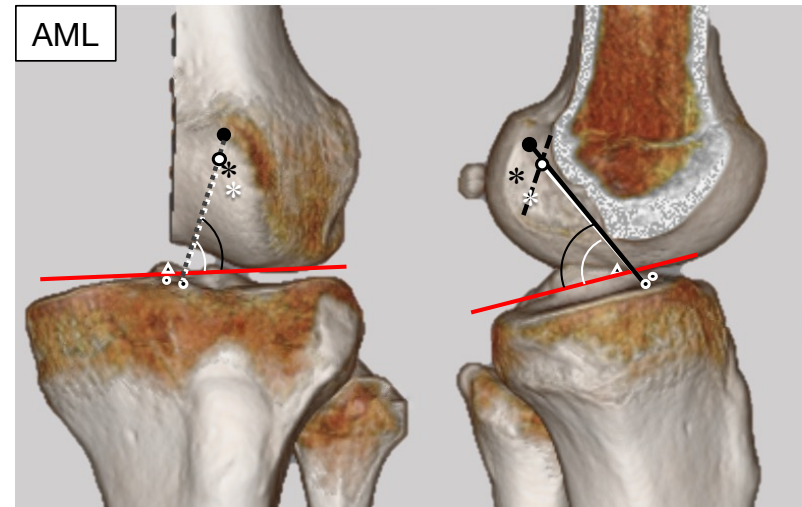
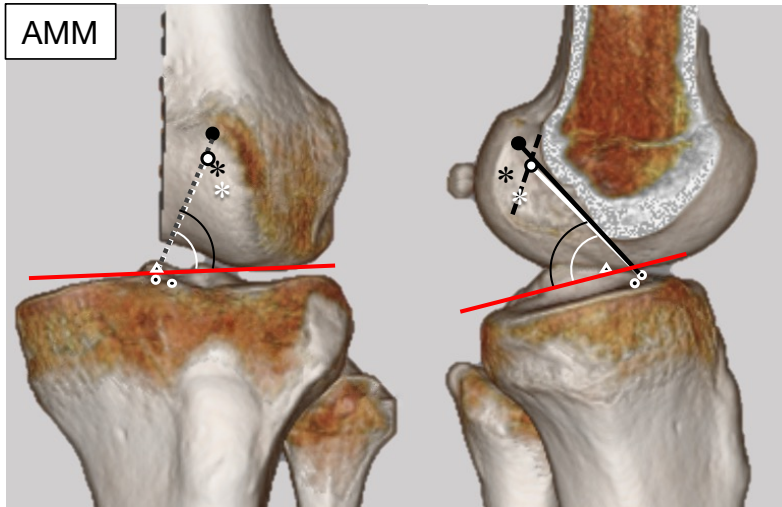
2. ACL/VACLG-TP angle



Friedman test with Bonferroni adjustment ($\alpha = 0.05/3 = 0.0167$)

**Statistically significant difference*

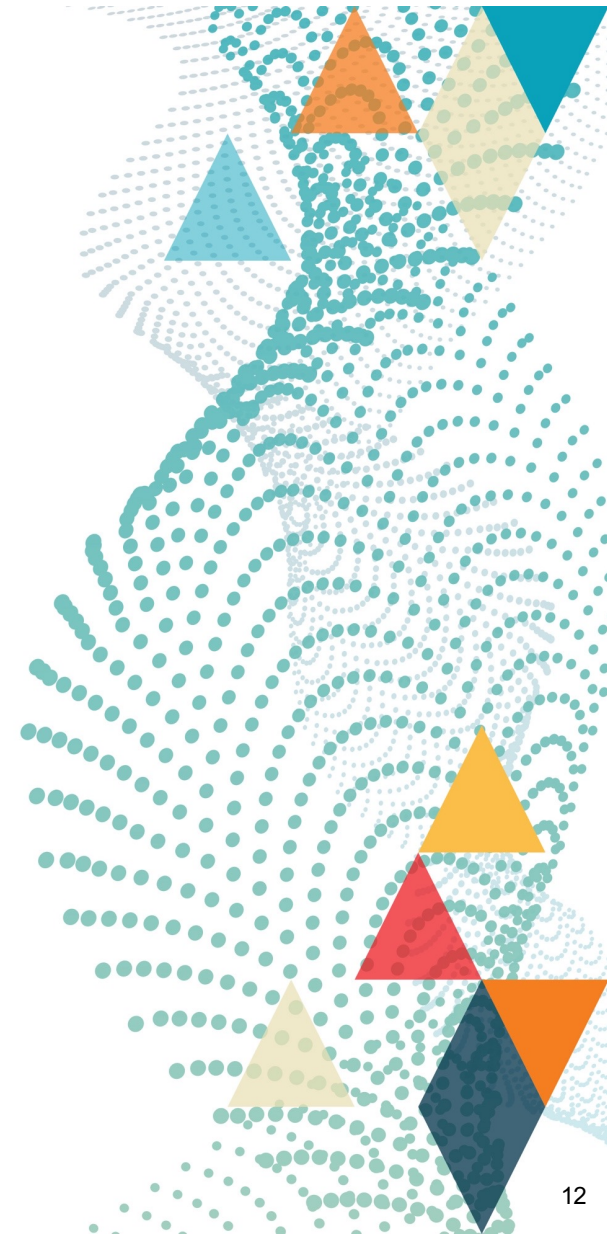
3. BR- vs OR-VACLG in VACLG-TP angle



- : Resident's ridge
- : Center of F-AM of BR-VACLG
- * : Center of F-PL of BR-VACLG
- : Center of F-AM of OR-VACLG
- * : Center of F-PL of OR-VACLG
- : BR-VACLG on the oblique-sagittal plane
- : OR-VACLG on the oblique-sagittal plane
- : BR-VACLG on the oblique-coronal plane
- : OR-VACLG on the oblique-coronal plane

Conclusion

The virtual triple-bundle ACL graft on the 3-D CT via the femoral tunnels **behind the resident's ridge** showed the equivalent orientation to the normal ACL on MRI.



References

1. Shino, K., Mae, T., & Tachibana, Y. (2015). Anatomic ACL reconstruction: rectangular tunnel/bone-patellar tendon-bone or triple-bundle/semitendinosus tendon grafting. *J Orthop Sci*, 20(3), 457–468.
2. Grasso, S., Linklater, J., Li, Q., & Parker, D. A. (2018). Validation of an MRI Protocol for Routine Quantitative Assessment of Tunnel Position in Anterior Cruciate Ligament Reconstruction. *Am J Sports Med*, 46(7), 1624–1631.
3. Bernard, M., Hertel, P., Hornung, H., & Cierpinski, T. (1997). Femoral insertion of the ACL. Radiographic quadrant method. *Am J Knee Surg*, 10(1), 14–22.
4. Tsukada, H., Ishibashi, Y., Tsuda, E., Fukuda, A., & Toh, S. (2008). Anatomical analysis of the anterior cruciate ligament femoral and tibial footprints. *J Orthop Sci*, 13(2), 122–129.
5. Take, Y., Shino, K., Mae, T., Tachibana, Y., Iuchi, R., Nakagawa, S., & Nakata, K. (2018). Early Structural Results After Anatomic Triple Bundle Anterior Cruciate Ligament Reconstruction Validated by Tunnel Location, Graft Orientation, and Static Anteroposterior Tibia-Femur Relationship. *Arthroscopy*, 34(9), 2656–2665.