IG GTR9-PH2 Task Force Bumper Test Area
7th Meeting, 28 August & 9 September 2014

Comparison of the FlexPLI Knee Element with a Human Knee

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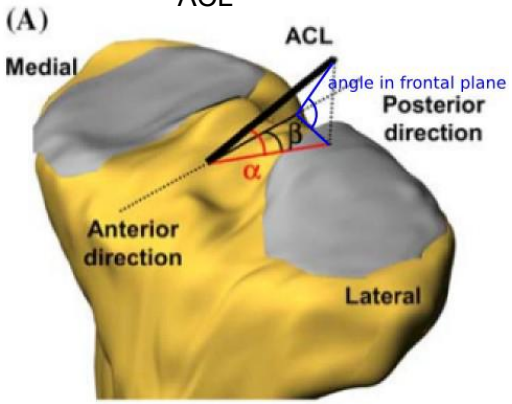
VDA | Verband der Automobilindustrie

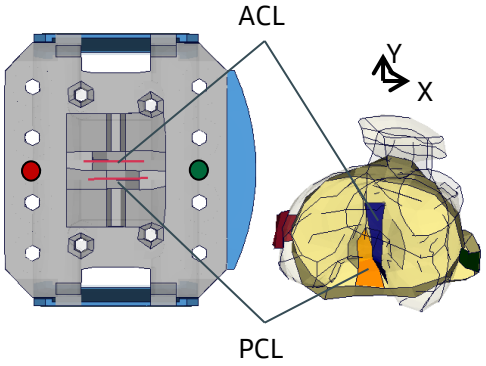
Geometry : FlexPLI vs. Human

β_{ACL} = 11°
α_{ACL} = 65°

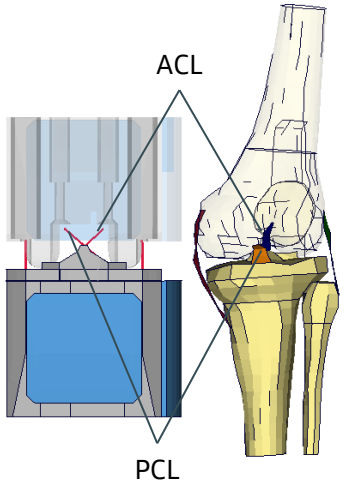


ACL Angle in a human knee [1]

β_{ACL} = 90°
α_{ACL} = 43°



Upper view of the FlexPLI and THUMS

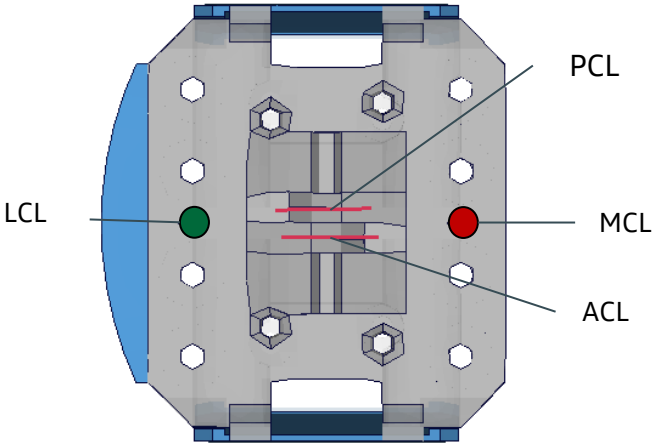


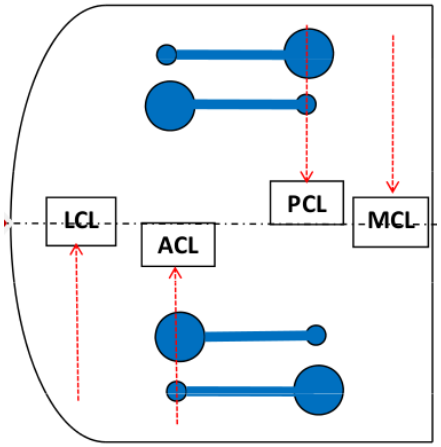
Posterior view of the FlexPLI and THUMS

- The arrangement and orientation of the cruciate ligaments (ACL and PLC) of the FlexPLI differ from human anthropometry
  - e.g. Angle ACL
    - β angle – Flex PLI : 90° / Human mean value : 11° [1]
    - α angle – Flex PLI : 43 ° / Human mean value : 65 ° [1]

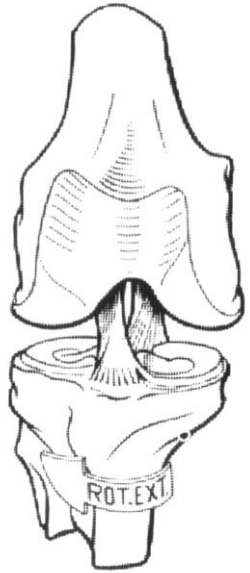
[1] Li G, DeFrate LE, Rubash HE, Gill TJ. 2005. In vivo kinematics of the ACL during weight-bearing knee flexion. Journal of Orthopaedic Research. 23(2):340-344

Geometry : FlexPLI vs. Human





Upper view of the FlexPLI

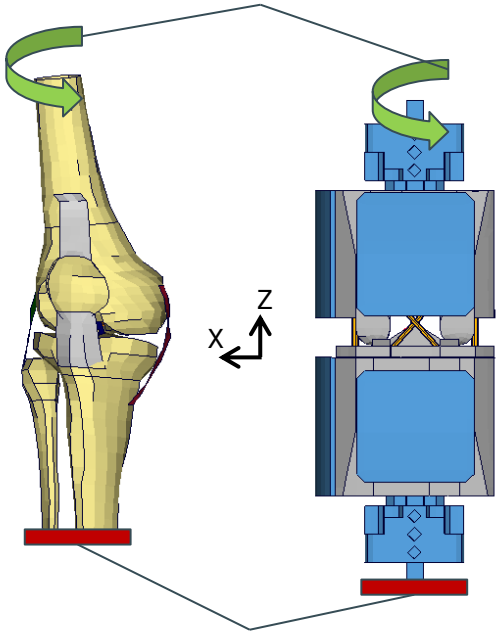


Human external rotation of lower leg

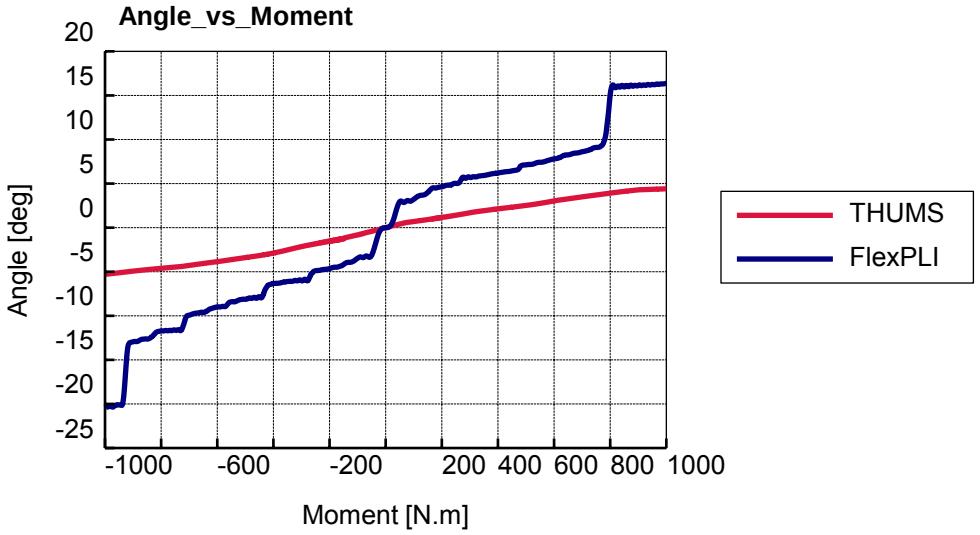
- The FlexPLI is not able to reproduce the ACL/PCL behaviour of the human ACL/PCL in knee rotation
  - Cruciate ligaments stress level depends on rotation that cannot be reproduced by the FlexPLI

Torsion FlexPLI vs. THUMS

Femur fixed in translation (X,Y,Z) and rotation (X,Y)
Rotation imposed by rotation velocity/torque (Z)



Tibia fixed in translation (X,Y,Z) and rotation (X,Y,Z)

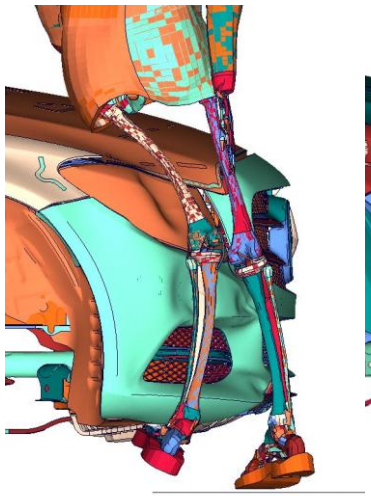


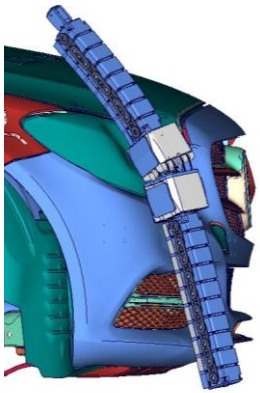
- Torque imposed to the femur
  - → 1000 N.m in 125 ms

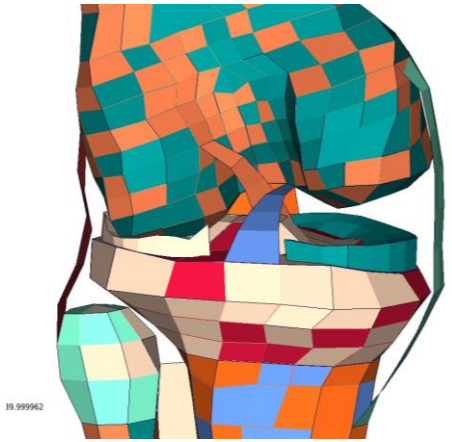
- **For the same imposed moment, the corresponding rotation is significantly higher with the FlexPLI**

- Maximal reached angles:
  - THUMS : [-5° ; +4°]
  - FlexPLI : [-20°;+16°]

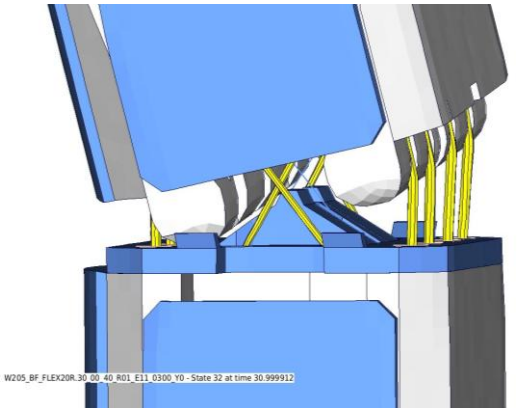
FlexPLI vs. THUMS







Comparison THUMS vs. FlexPLI



- **Large rotation of FlexPLI leading to higher PCL-values**
  - THUMS elongation : ACL 2mm / PCL 1mm
    →Almost no loading in lateral position
  - FlexPLI elongation : PCL 10 mm
    →Large loading due to design of ACL/PCL

Conclusion

- The arrangement and orientation of the cruciate ligaments of the FlexPLI differs from the human anthropometry
- The FlexPLI is not able/meaningful to reproduce the ACL/PCL behaviour of the human ACL/PCL in knee rotation
  - Cruciate ligaments stress level depends on rotation that cannot be reproduced by the FlexPLI
- For the same torque applied to the knee, FlexPLI torsion-angle is significantly higher
- Large rotation of FlexPLI leads to higher PCL-values than the THUMS
- **Test conditions in which rotation occurs are not representative of the human knee behaviour**

Thank you!