# Clarification of Injury Threshold Determination Process Used by JAMA

Action List Item 1. j)
Evaluate and decide on performance / injury criteria and threshold values

5th IG GTR9-PH2 Meeting
6-7/December/2012
Japan Automobile Manufacturers Association (JAMA)
Pedestrian Safety Experts Group

# Flex-TEG Agreement

TEG-127

TEG-127

7 December 2009

**Technical Background Information Document for the UN-ECE GRSP explaining the Derivation of Threshold Values and Impactor Certification methods for the FlexPLI version GTR agreed by the FlexPLI-TEG at their 9th Meeting**

**Drafted by: Atsuhiro Konosu (JARI/J-MLIT) and Oliver Zander (BASt) on behalf of the GRSP FlexPLI Technical Evaluation Group (TEG)**

**1) Tibia Threshold Value: 340 Nm**

At the 8th GRSP Flex-TEG meeting on May 19th, 2009, two proposals for the tibia threshold value of the FlexPLI version GTR (also called Flex-GTR) were made by JAMA and BASt, coming to different conclusions.

**a) 380 Nm (JAMA)**

JAMA derived the Flex-GTR tibia bending moment threshold using a linear transition equation between human and Flex-GTR Finite Element (FE) models derived from computer simulation results. The average human tibia bending moment threshold value was taken from an injury risk curve of the 50th percentile male for tibia fracture, taking into account scaled male and female PMHS data from Nyquist et al. (1985) and Kerrigan et al. (2004) under modification of the standard tibia length and standard tibia plateau height, making the assumption that the height scale factor and length scale factor should correlate to each other. The Weibull Survival Model was used to develop the injury probability function. The proposed final threshold value resulted in 380 Nm.

**b) 302 Nm (BASt)**

BASt derived the Flex-GTR tibia bending moment threshold also using the corresponding transition equation between human and Flex-GTR FE models. The average human tibia bending moment threshold value was taken from an injury risk curve of the 50th percentile male for tibia fracture, taking into account scaled male PMHS data from Nyquist et al. (1985) using the standard tibia plateau height provided by DIN 33402-2 German anthropometrical database. The cumulative Gaussian distribution was used to develop the injury probability function. The calculated threshold value under consideration of possible scatter of test results and of a reproducibility corridor derived from inverse certification test results was 302 Nm.

A comparison of both approaches revealed that the calculated threshold values mainly depend on

- the underlying set of PMHS data

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As this was almost the value proposed by BASt as average value between the BASt and former JAMA proposals, the group agreed at the 9th TEG meeting on September 3rd – 4th, 2009, on a consensus of the rounded value of 340 Nm.

2) **MCL Elongation Threshold Value: 22 mm**

a) **22 mm (JAMA)**

JAMA developed an MCL injury risk function as average function between the risk functions from Ivarsson et al. (2004) and Konosu et al. (2001), latter one revised using the Weibull Survival Model. In this function, a 50% risk of knee injury in terms of MCL rupture corresponded to a human knee bending angle of 19 degrees. This value was converted to 19.1 mm MCL elongation, using a corresponding transition equation from computer simulation. After incorporating the effect of muscle tone the threshold value was calculated at 21 mm. As this value was converted to 16.9 degrees of EEVC WG 17 PLI knee bending angle by using a corresponding transition equation which would be by 11 % more conservative than the currently defined GTR threshold value of 19 deg, a 5% more conservative approach, equal to 18 deg EEVC WG 17 PLI knee bending angle was proposed and transformed to 22 mm MCL elongation, using the same transition equation as before.

b) **22 mm (BASt)**

As BASt is not in the position to validate or double-check those results, they investigated a direct correlation between the EEVC WG 17 PLI knee bending angle and the FlexPLI MCL elongation as verification of the JAMA results. A transition equation was developed, based on hardware test results of different vehicle categories and idealized tests. Thus, a knee bending angle of 19 degrees would correspond to 22.7 mm MCL elongation. In order to provide at least the same level of protection as the current GTR, a threshold value of 22 mm was proposed which was in line with the JAMA proposal

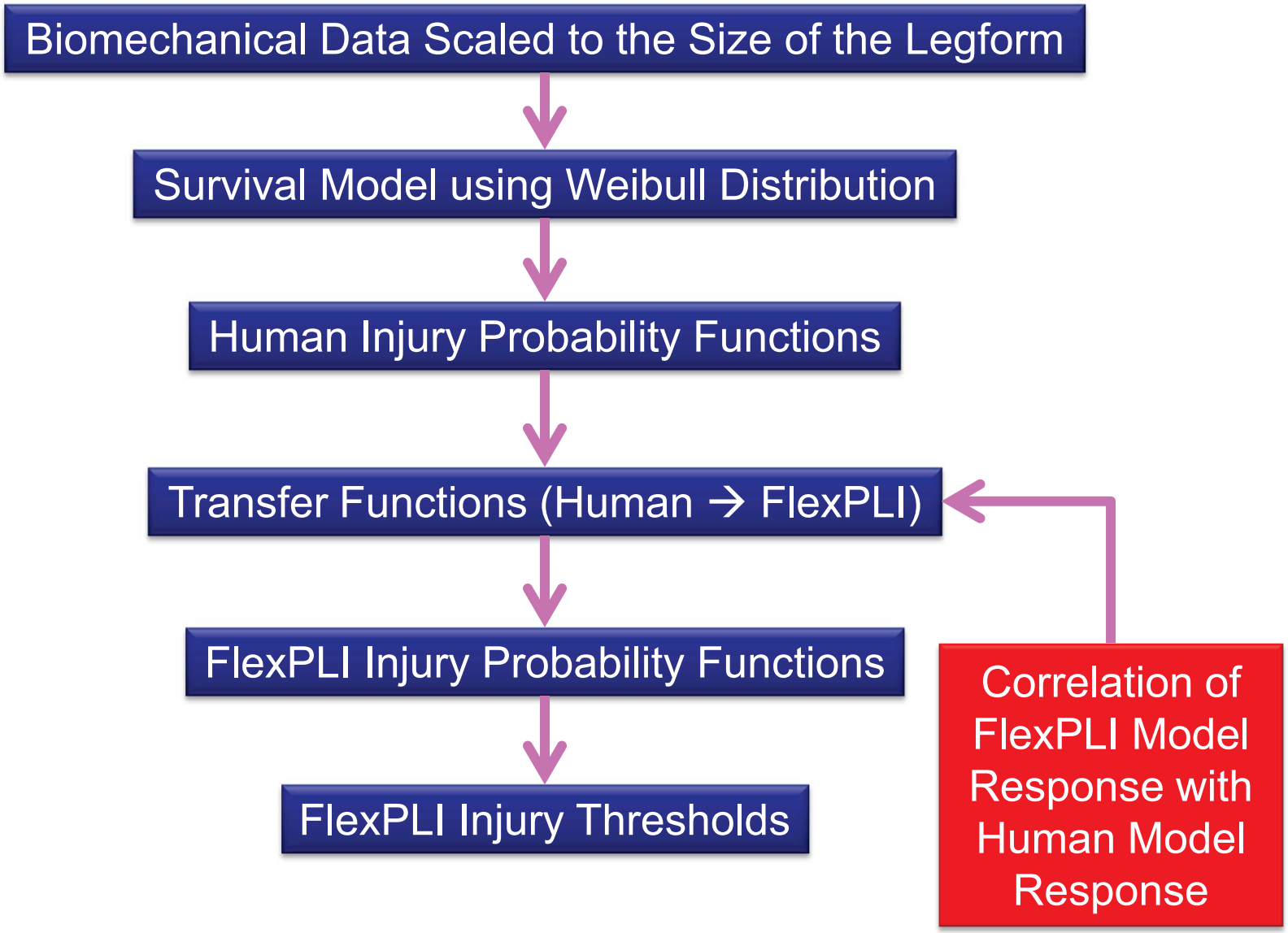
At the 9th GRSP Flex-TEG meeting on September 3rd - 4th, 2009, the group agreed on a Flex-GTR threshold value for MCL elongation of 22 mm.

3) **ACL/PCL Elongation Threshold Value**

a) **Mandatory with a threshold of 13 mm (BASt)**

Currently, no injury risk curve for cruciate ligament injuries is available. BASt proposed to therefore use the results of PMHS tests described by Bhalla et al. (2003), stating that below a shear

# JAMA Threshold Determination Process




**All the details provided in GTR9-1-06r1**

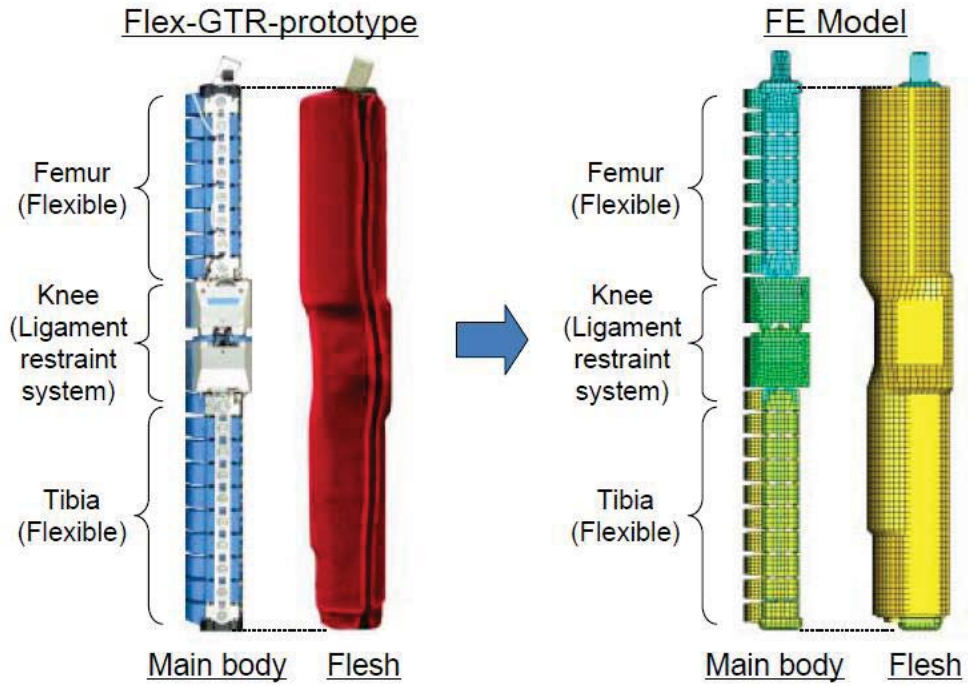
# FlexPLI Model Validation

GTR9-5-12

TEG-096

## FlexPLI Model

**Flex-GTR-prototype and Developed FE model (Overview)**




Reference : JAMA/JARI, *Development of a FE Flex-GTR-prototype model and Analysis of the Correlation between the Flex-GTR-prototype and Human Lower Limb Outputs using Computer Simulation Models,* 8th Flex-TEG Meeting Document, TEG-096 (2009)

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## FlexPLI Model

**Flex-GTR-prototype models**

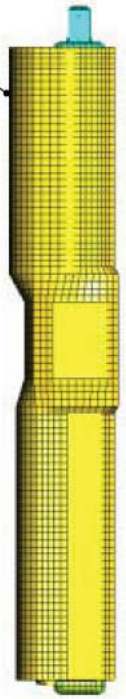
Flex-GTR-prototypemodel

Impact Side

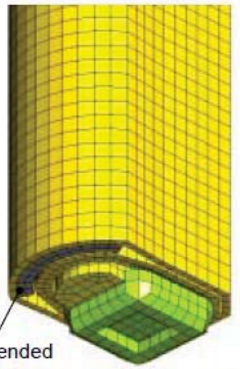
Flex-GTR-prototype model has similar constructions of an actual one.

Flex-GTR-prototype "extended rubber" model

Impact Side



Flex-GTR-prototype "extended rubber" model has improved structure of flesh. Rubber is extended to a Tibia bottom end. (Based on BASt/BGS proposal)



Extended rubber

Tibia bottom end

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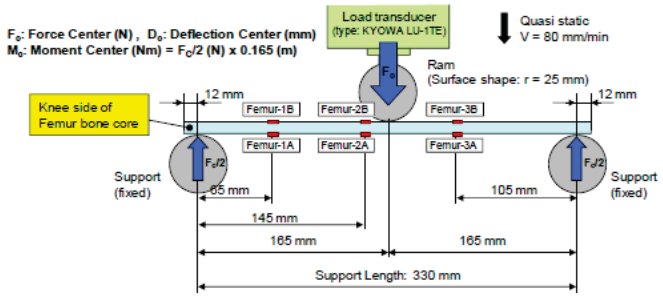
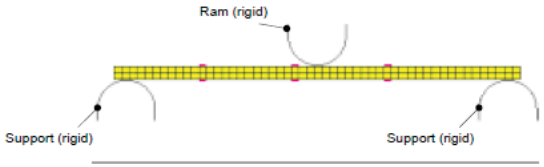
## FlexPLI Model

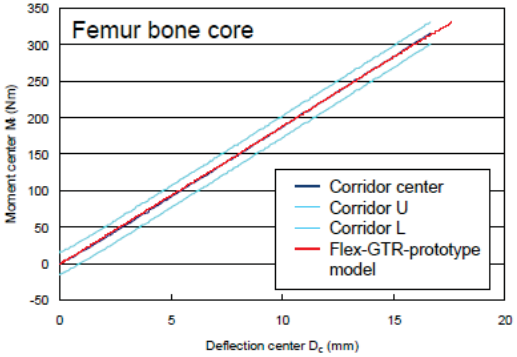
### Femur bone core 3-point bending validation

Test setup for Femur bone core 3-point bending validation




Model setup for Femur bone core 3-point bending validation

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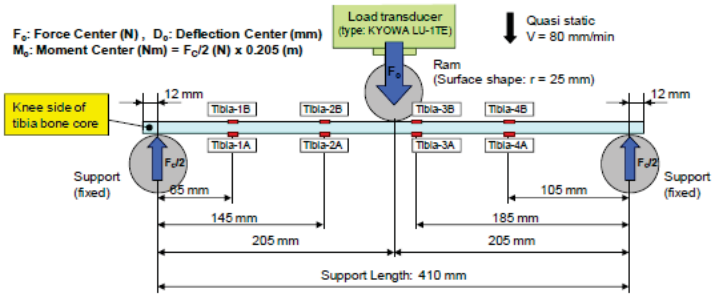
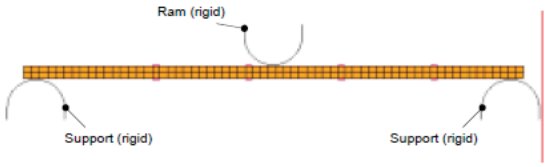
## FlexPLI Model

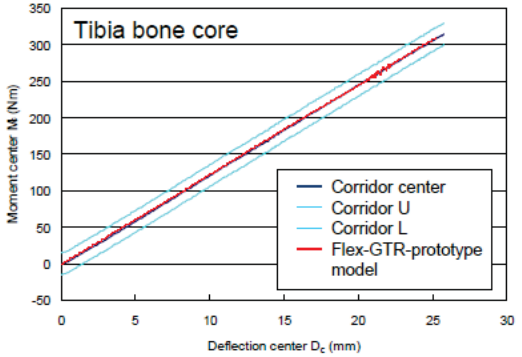
### Tibia bone core 3-point bending validation

Test setup for Tibia bone core 3-point bending validation




Model setup for Tibia bone core 3-point bending validation

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# FlexPLI Model Validation

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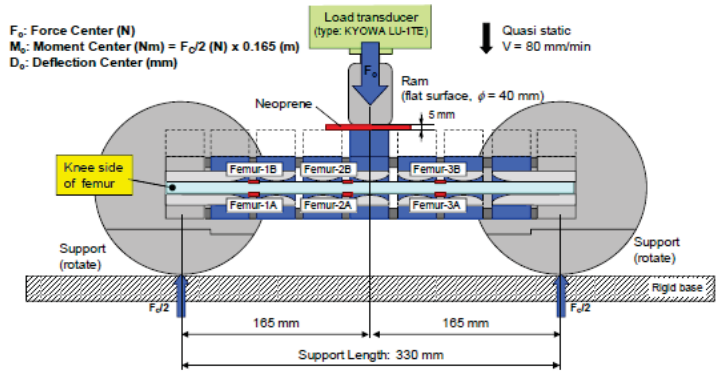
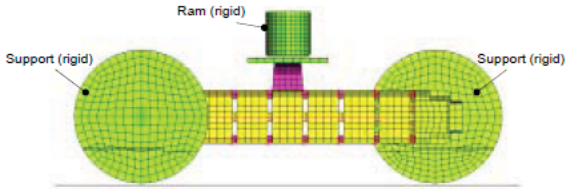
## FlexPLI Model

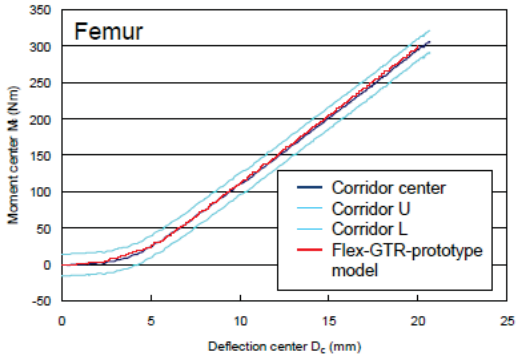
### Femur 3-point bending validation

Test setup for Femur 3-point bending validation




Model setup for Femur 3-point bending validation

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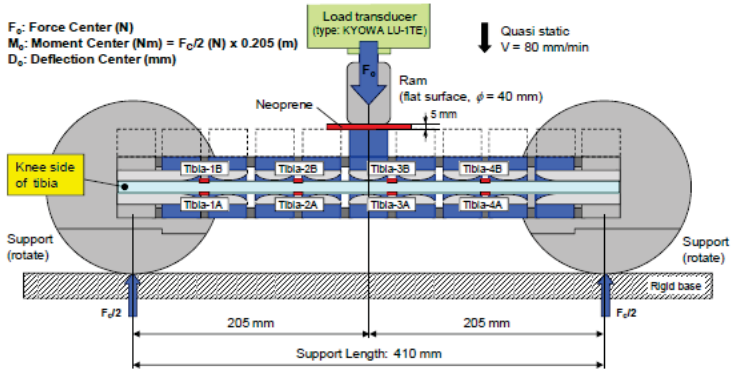
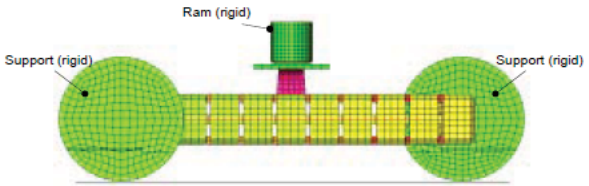
## FlexPLI Model

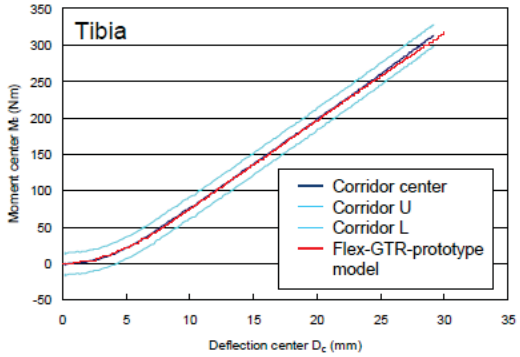
### Tibia 3-point bending validation

Test setup for Tibia 3-point bending validation




Model setup for Tibia 3-point bending validation

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# FlexPLI Model Validation

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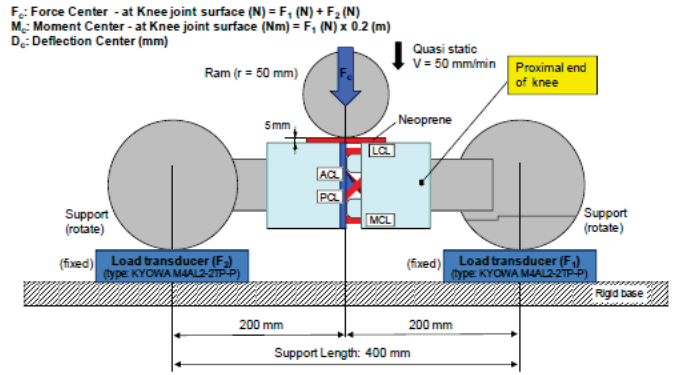
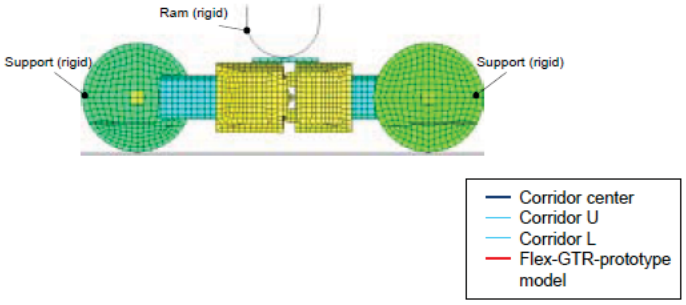
## FlexPLI Model

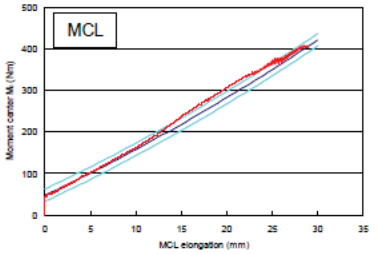
### Knee 3-point bending validation

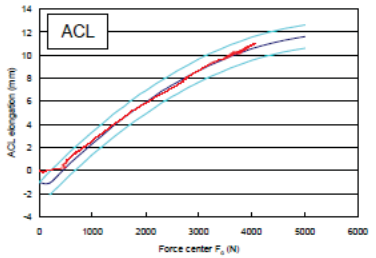
Test setup for Knee 3-point bending validation

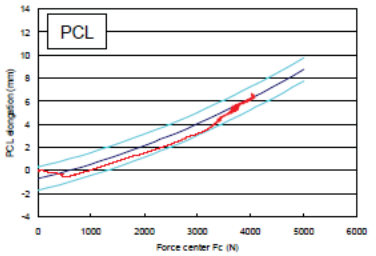



Model setup for Knee 3-point bending validation

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# Summary

- FlexPLI model used to develop transfer functions was validated against component corridors, not against actual (prototype / production) legform
- Transfer functions will not be affected unless component corridors are changed
- Injury thresholds will not be affected unless transfer functions are affected
- Procedure from which JAMA derived 340 Nm and 22 mm has nothing to do with inverse certification corridors
- JAMA proposals of 340 Nm and 22 mm will not be changed despite the modifications to the dynamic certification corridors

# *Thank you for your attention*