TEG-097

Injury Criteria for Flex-GTR MCL and Tibia
- JAMA Proposal -

The Japan Automobile Manufacturers Association Inc.
Pedestrian Safety WG

Proposed Human Thresholds

Proposal for Human MCL Threshold

- No data duplication between Konosu et al. (2001) and Ivarsson et al. (2004) : simple average can be justified to take into account as many data as possible
- Data scaling does not affect injury risk functions for the MCL (bending angle) in both Konosu et al. and Ivarsson et al.
- Use of Injury Definition B in Ivarsson et al. is more appropriate to reasonably represent failure of the MCL
- 95% CI curves in Ivarsson et al. should not be used because the estimated risk function provide the best fit to the data

- Proposed bending angle threshold for human MCL : **19 deg** (virtually the same as previously proposed value)
- Flex-GTR MCL elongation threshold needs to be investigated based on the response correlation between the Flex-GTR and human lower limb

Proposed Thresholdfor Human MCL

Knee Bending Angle 19 deg

Proposal for Human Tibia Moment Threshold

- Only data used by Kerrigan et al. (2004) were used in order to avoid duplicated data entry
- Unscaled data resulted in different injury risk curve from that obtained using modified scale factors with the average scale factor identical to the average height scale factor
- Although the average height of the specimens was close to that of 50th percentile male, data scaling should allow more appropriate threshold for the Flex-PLI that represents 50th percentile male anthropometry

- Proposed bending moment threshold for human tibia : **361 Nm**
- Flex-GTR tibia bending moment threshold needs to be investigated based on the response correlation between the Flex-GTR and human lower limb

Proposed Thresholdfor Human Tibia

Tibia Bending Moment 361 Nm

MCL Injury Measure Conversion

Convert: Human value >>> Flex-GT value

TEG-035

Human	Human Model	Flex-GT Model	Flex-GT
Tibia bending moment	Tibia bending moment	Tibia bending moment	Tibia bending moment
H_{TBM} (Nm)	HM_{TBM} (Nm)	$FGTM_{TBM}$ (Nm)	FGT_{TBM} (Nm)
312	312	299	299
350	350	337	337

Tentative threshold values

assumption: $H_{TBM} = HM_{TBM}$, $FGT_{MTBM} = FGT_{TBM}$

$FGT_{MTBM} = 0.9977 * HM_{TBM} - 12.325$ (from reguration curve)

Human	Human Model	Human Model	Flex-GT model	Flex-GT
Knee bending angle	Knee bending angle	Knee MCL elongation	Knee MCL elongation	Knee MCL elongation
H_{KBA} (deg.)	HM_{KBA} (deg.)	HM_{MCL} (mm)	$FGTM_{MCL}$ (mm)	FGT_{MCL} (mm)
18	18	15	18	18
20	20	17	20	20

assumption: $H_{KBA} = HM_{KBA}$, $FGT_{MMCL} = FGT_{MCL}$

$HM_{MCL} = 0.835 * HM_{KBA}$ (from human model output)

$FGTM_{MCL} = 0.6924 * HM_{MCL} + 8.0156$ (from reguration curve)

Convert human tolerance values to the Flex-GT ones (use correlation ratio/formula)

- Tibia Bending Moment for Human Model : **361 Nm**
- MCL Elongation for Human Model : 0.835*19 deg = **15.9 mm**

JAMA Proposal at 7th Flex-TEG

(TEG-076)

Human Thresholds

↓

Human → Flex-PLI

- Correlation between Flex-GT and human model responses using simplified car models **INCLUDING** high bumper vehicles
- Incorporation of estimated effect of muscle tone for MCL

↓

Flex-PLI Thresholds

Question was raised regarding the representativeness of the simplified vehicle models for high bumper vehicles

Human -> Flex-GTR Conversion

Human Thresholds

Human → Flex-PLI

- Correlation between Flex-GT and human model responses using simplified car models **NOT INCLUDING** high bumper vehicles
- Incorporation of estimated effect of muscle tone for MCL

Flex-PLI Thresholds

- Difficult to systematically represent high bumper vehicle fleet
- Decreased human – Flex-GTR correlation for high bumper vehicles

Human -> Flex-GTR Conversion

Human Thresholds

- Correlation between Flex-GT and human model responses using simplified car models **NOT INCLUDING** high bumper vehicles
- Incorporation of estimated effect of muscle tone for MCL

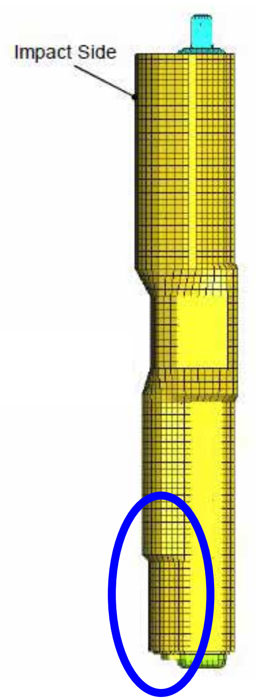
Flex-PLI Thresholds

Human

Flex-PLI

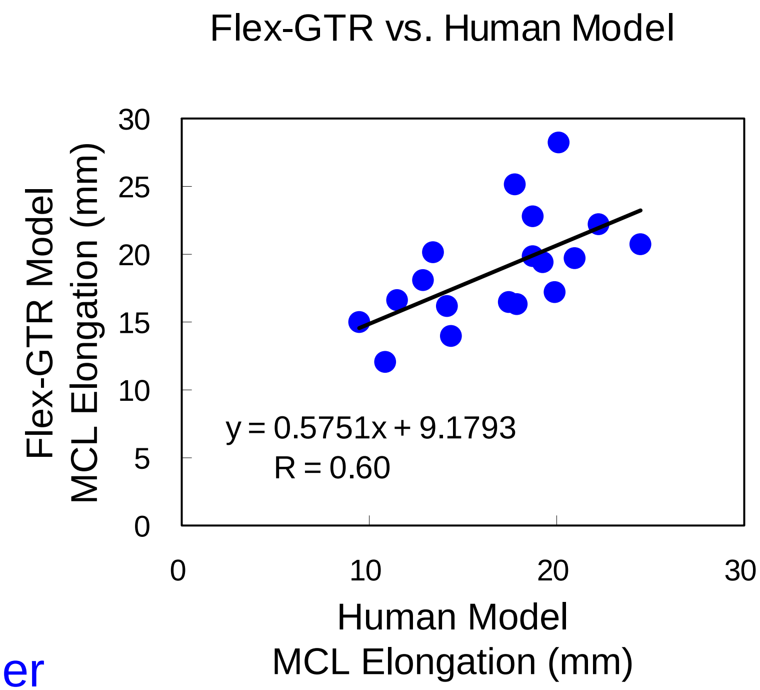
Human - Flex-GTR Response Correlation

Flex-GTR Prototype



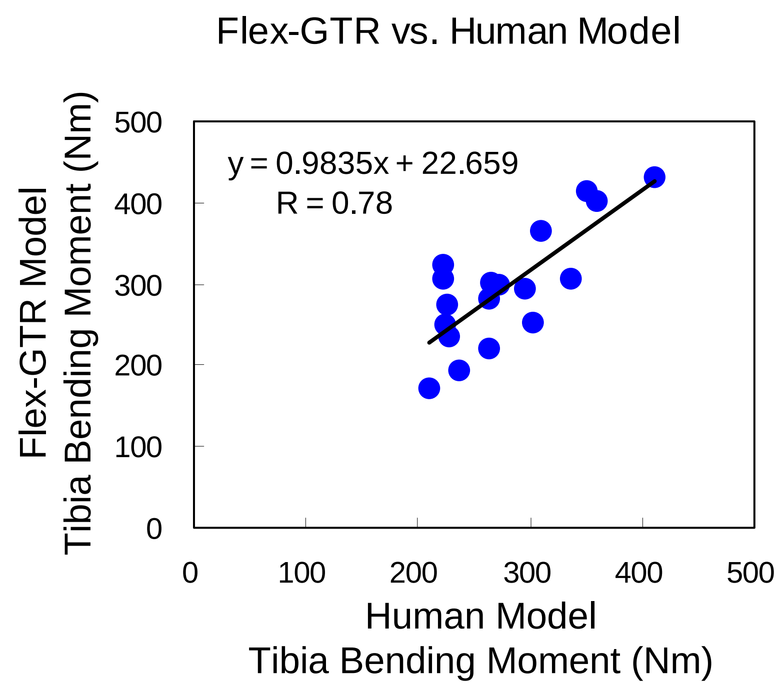
Original
Flesh Rubber

MCL



R = 0.60

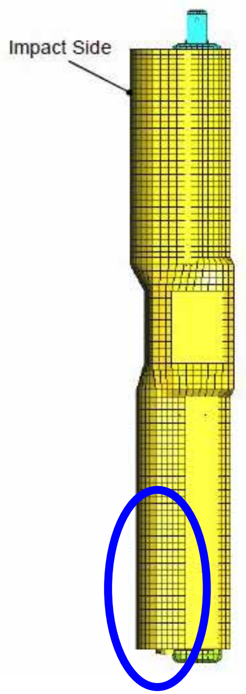
Tibia



R = 0.78

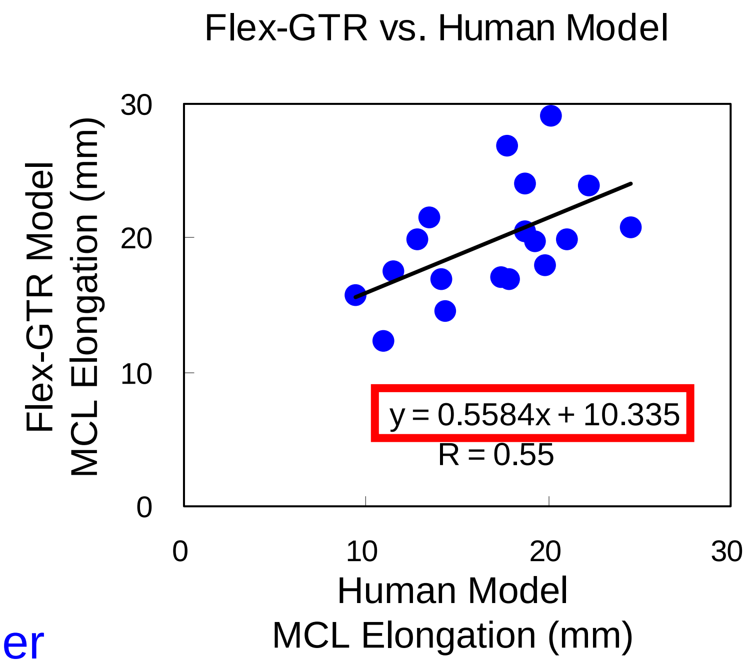
Human - Flex-GTR Response Correlation

Flex-GTR Prototype w/Extended Flesh Rubber



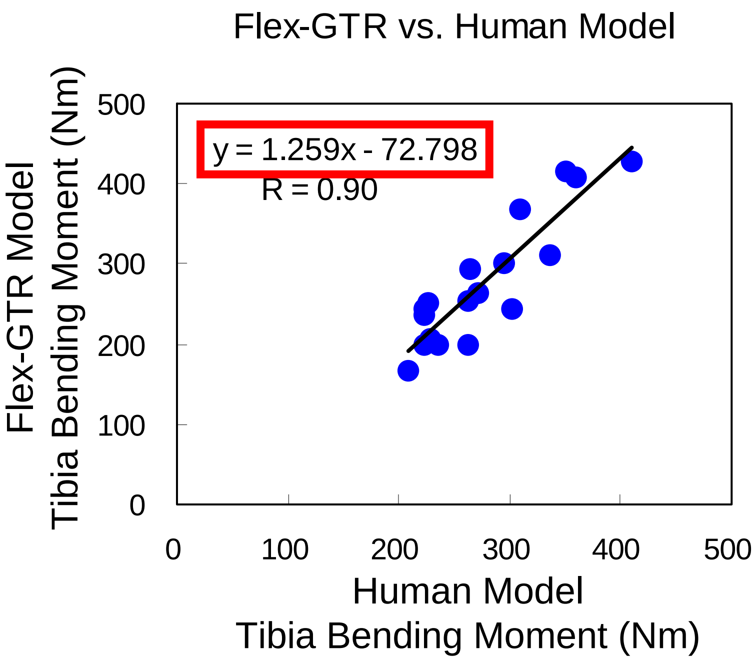
Extended
Flesh Rubber

MCL



R = 0.55

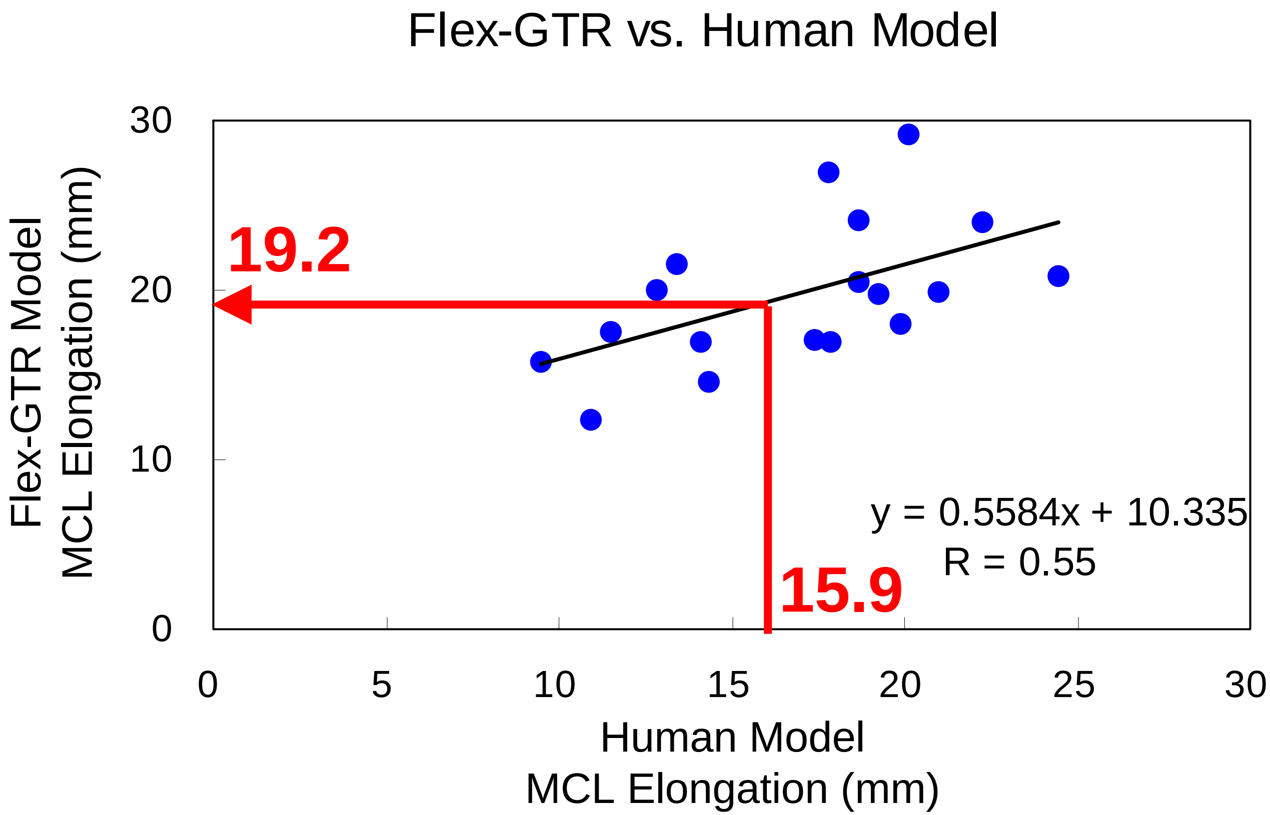
Tibia



R = 0.90

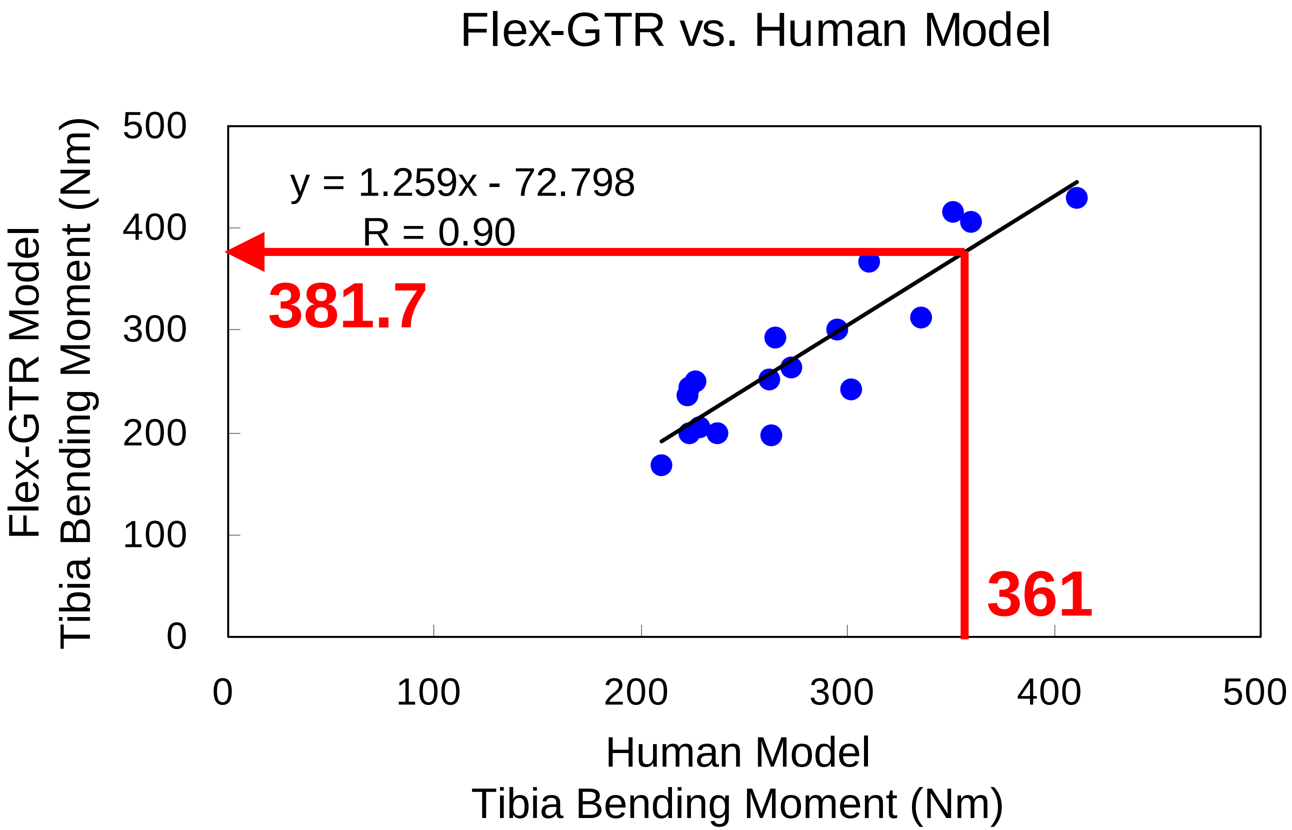
- Better correlation for tibia bending moment with extended flesh rubber
- Use results for extended flesh rubber to convert injury thresholds from human to Flex-GTR

MCL Threshold Conversion



Converted Flex-GTR MCL Elongation : **19.2 mm**

Tibia Threshold Conversion



Converted Flex-GTR Tibia Bending Moment :

381.7 Nm

Human -> Flex-GTR Conversion

Human Thresholds

- Correlation between Flex-GT and human model responses using simplified car models **NOT INCLUDING** high bumper vehicles
- Incorporation of estimated effect of muscle tone for MCL

Flex-PLI Thresholds

Human

Flex-PLI

Effect of Muscle Tone

gtr9 Preamble

(TEG-076)

110. These studies suggest a bending limit in the range of 15° to 21° for knee protection. The informal group determined that a value close to the upper limit (21°) of this range should be considered, and not the average. The absence of muscle tone in the PMHS tests reduced the knee stiffness of the subjects, and the high rigidity of the impactor bones transferred to the knee joint a part of the impact energy normally absorbed by the deformation of human long bones. For these reasons, a bending limit of 19° was selected for this gtr.

Lloyd and Buchanan (2001)

ELSEVIER

Journal of Biomechanics 34 (2001) 1257–1267

JOURNAL OF BIOMECHANICS

www.elsevier.com/locate/jbiomech
www.JBiomech.com

Strategies of muscular support of varus and valgus isometric loads at the human knee

David G. Lloyd[a,*], Thomas S. Buchanan[b]

[a] Department of Human Movement and Exercise Science, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia
[b] Department of Mechanical Engineering, University of Delaware, Newark, DE 19716, USA

Accepted 30 May 2001

The electromyographs (EMG) were recorded from the semitendinosus (ST), biceps femoris long head (BFL),

vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF), tensor fasciae lata (TFL), gracilis (GR), sartorius (SR), and medial and lateral gastrocnemius (MG and LG). The EMG from SR, GR and TFL were

our previous paper (Buchanan and Lloyd, 1997), the HAMs (BFL, BFS, ST, SM) and the QUADs (RF, VM, VI, VM) were grouped into functional units because of these muscles' strongly directed activation patterns towards flexion and extension (see Fig. 3A in Buchanan and Lloyd, 1997). The TFL, GR, SR, MG and LG were all analysed separately based on their directed activation patterns to support varus and/or valgus moments (see

David G. Lloyd, Thomas S. Buchanan
Strategies of muscular support of varus and valgus isometric loads at the human knee
J. of Biomechanics 34 (2001) 1257-1267

- For volunteers, average contribution to varus is 17 ± 9.7% and **to valgus is 10 ± 6.3%** of externally applied moment
- Flex-GTR MCL threshold incorporating effect of muscle tone : 19.2 mm * 1.1 = **21.1 mm**

Proposal for Flex-GTR Injury Threshold

- Correlation functions derived from data NOT INCLUDING high bumper vehicles were used for threshold conversion
- Correlation functions with an extended flesh rubber were used for significantly improved correlation for the tibia bending moment
- Converted thresholds were 19.2 mm for MCL, and 381.7 Nm for Tibia
- Incorporation of muscle tone effect yielded the MCL elongation threshold of 21.1 mm

- Proposed elongation threshold for Flex-GTR MCL : **21 mm**
- Proposed bending moment threshold for Flex-GTR tibia : **380 Nm**