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Impact Parameter Tolerances for Inverse Certification Test and Vehicle Testing

**10th Meeting of the GRSP Flex PLI Technical Evaluation Group
Bergisch Gladbach, December 1st – 2nd, 2009**

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(Federal Highway Research Institute)

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- Test setup**
- Temperature corridor**
- Impact velocity corridor**
- Impact height tolerance**
- Pitch angle tolerance**
- Roll angle tolerance**
- Yaw angle tolerance**

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Test setup

Temperature corridor

Impact velocity corridor

Impact height tolerance

Pitch angle tolerance

Roll angle tolerance

Yaw angle tolerance

Test setup (1)

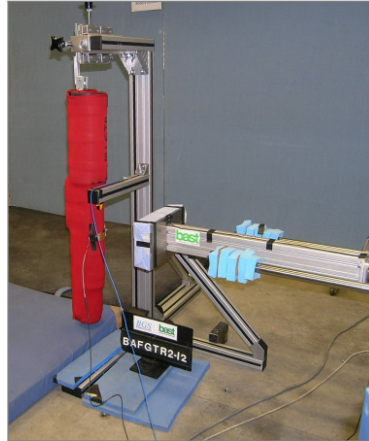
- Inverse certification setup with Flex-GT
- Variation of impact parameters
- Three baseline tests:
 - T = 20 °C
 - Impact velocity = 11,1 m/s
 - Impact height = 0 mm
 - Pitch, roll and yaw angle = 0°
- Six tests w/ variation of temperature (3*16 °C, 3*24 °C)
- Six tests w/ variation of impact velocity (3*10,6 m/s, 3*11,6 m/s)
- Six tests w/ variation of impact height (3*-10 mm, 3*10 mm)
- Six tests w/ variation of pitch angle (3*-5°, 3*5°)
- Six tests w/ variation of roll angle (3*-5°, 3*5°)
- Six tests w/ variation of yaw angle (3*-5°, 3*5°)
- Total number of 39 tests



Test setup (2)



- Inverse certification setup with Flex-GTR
- Variation of impact parameters
- Three baseline tests:
 - T = 20 °C
 - Impact velocity = 11,1 m/s
 - Impact height = 0 mm
 - Pitch, roll and yaw angle = 0 °
- Twelve tests w/ variation of impact velocity (3*10,1 m/s, 3*10,6 m/s, 3*11,1 m/s, 3*11,6 m/s)
- Six tests w/ variation of impact height (3*-10 mm, 3*+10 mm)
- Six tests w/ variation of yaw angle (3*-10°, 3*+10°)
- Total number of 27 tests



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Test setup

Temperature corridor

Impact velocity corridor

Impact height tolerance

Pitch angle tolerance

Roll angle tolerance

Yaw angle tolerance

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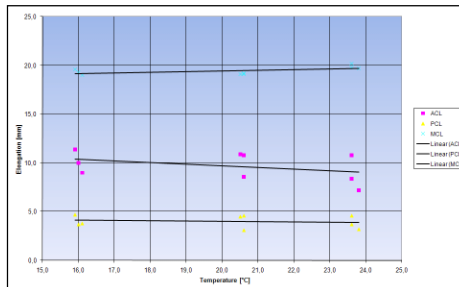
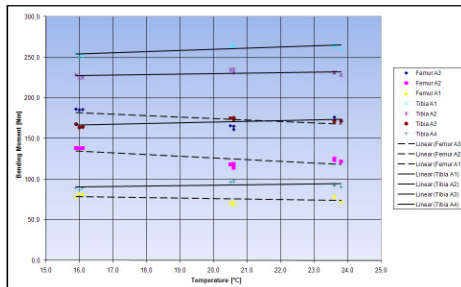
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Variation of temperature



- Current proposal: $T=20\pm 4$ °C (Inverse certification and vehicle tests)
- Six Flex GT tests w/ variation of temperature (3×16 °C, 3×24 °C)
- Comparison with baseline tests



- Clear correlation between ambient and impactor temperature and femur / tibia output
- Corridor is proposed to be held as tight as possible for both certification and vehicle tests:
Inverse certification test: $T=20\pm 2$ °C
Vehicle test: $T=20\pm 4$ °C

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Content



- Test setup
- Temperature corridor
- Impact velocity corridor**
- Impact height tolerance
- Pitch angle tolerance
- Roll angle tolerance
- Yaw angle tolerance

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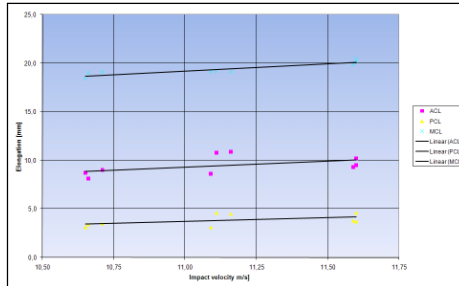
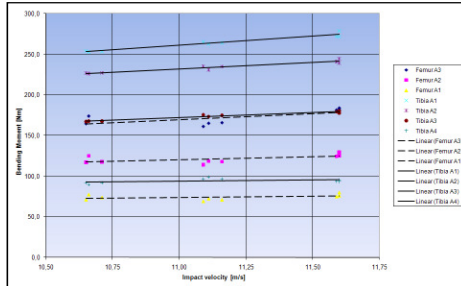
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Variation of impact velocity (1)



- Current proposal: $v=11,1\pm 0,2$ m/s (Inverse certification and vehicle tests)
- Six Flex GT tests w/ variation of impact velocity (3*10,6 m/s, 3*11,6 m/s)
- Comparison with baseline tests



- Clear correlation between impact velocity and impactor output

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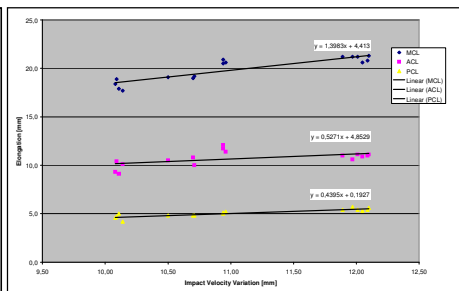
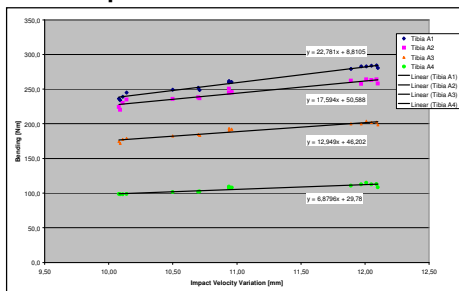
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Variation of impact velocity (2)



- Twelve Flex GTR tests w/ variation of impact velocity (3*10,1 m/s, 3*10,6 m/s, 3*11,1 m/s, 3*11,6 m/s)
- Comparison with baseline tests



- Clear correlation between impact velocity and impactor output
- Corridor is proposed to be held as tight as possible for both certification and vehicle tests:
 $v=11,1\pm 0,2$ m/s

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Test setup
Temperature corridor
Impact velocity corridor
Impact height tolerance
Pitch angle tolerance
Roll angle tolerance
Yaw angle tolerance

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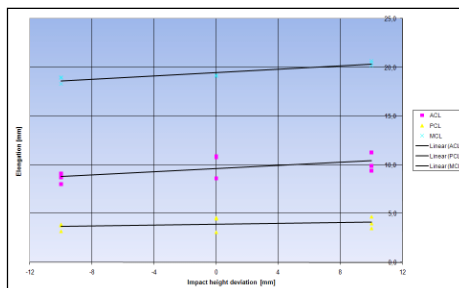
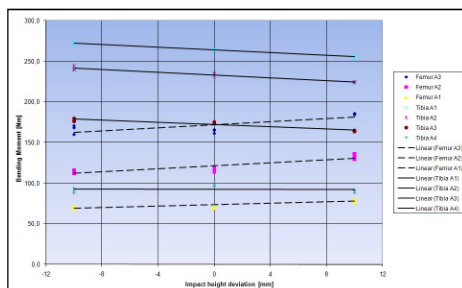
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Variation of impact height (1)



- **Current proposal:**
 $h=0\pm 3$ mm (Inverse certification) / $h=75\pm 10$ mm (vehicle tests)
- **Six Flex GT tests w/ variation of impact height**
(3^*-10 mm, 3^*+10 mm)
- **Comparison with baseline tests**



- **Clear correlation between impact height and impactor output**

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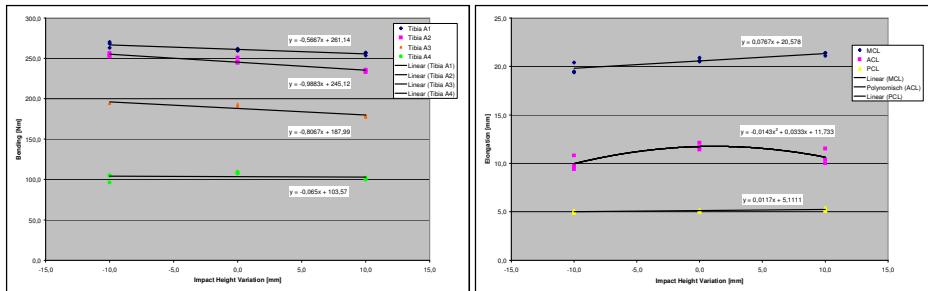
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Variation of impact height (2)



- Six Flex GTR tests w/ variation of impact height (3*-10 mm, 3*+10 mm)
- Comparison with baseline tests



- Clear correlation between impact height and impactor output
- Corridor is proposed to be held as tight as possible:
Inverse certification test: $h=0\pm 2$ mm
Vehicle test: $h=75\pm 8$ mm

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Content



- Test setup
- Temperature corridor
- Impact velocity corridor
- Impact height tolerance
- Pitch angle tolerance**
- Roll angle tolerance
- Yaw angle tolerance

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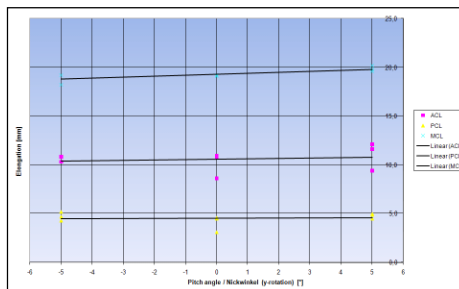
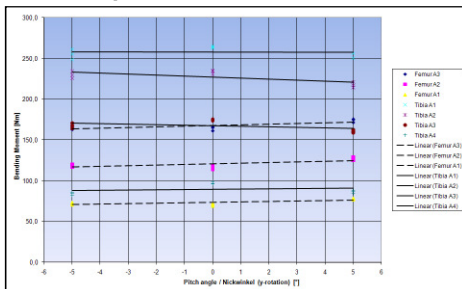
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Pitch angle tolerance



- Current proposal: $0 \pm 2^\circ$ (Inverse certification and vehicle tests)
- Six Flex GT tests w/ variation of pitch angle ($3^* - 5^\circ$, $3^* + 5^\circ$)
- Comparison with baseline tests



- Influence of impactor pitch angle on especially femur and MCL results
- Corridor is proposed to be held as tight as possible for both certification and vehicle tests:
Impactor pitch angle at the point of first contact = $0 \pm 2^\circ$

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- Test setup
- Temperature corridor
- Impact velocity corridor
- Impact height tolerance
- Pitch angle tolerance
- Roll angle tolerance**
- Yaw angle tolerance

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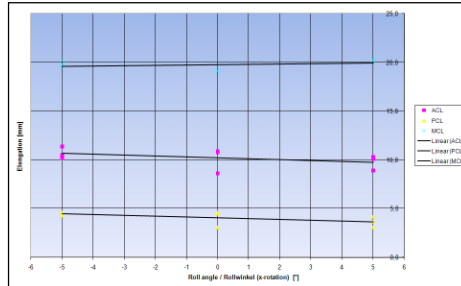
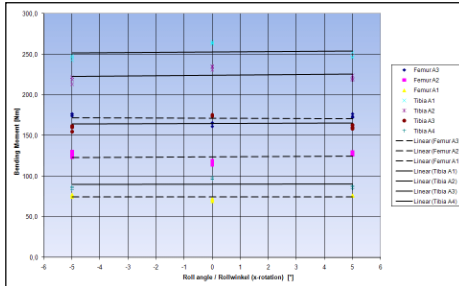
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Roll angle tolerance



- Current proposal: $0 \pm 2^\circ$ (Inverse certification and vehicle tests)
- Six Flex GT tests w/ variation of roll angle ($3^* - 5^\circ$, $3^* + 5^\circ$)
- Comparison with baseline tests



- Obvious influence of impactor roll angle on cruciate ligament results only
- Anyway, in case ACL/PCL are foreseen as GTR injury criteria, corridor is proposed to be held as tight as possible for both certification and vehicle tests:
Impactor roll angle at the point of first contact = $0 \pm 2^\circ$

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- Test setup
- Temperature corridor
- Impact velocity corridor
- Impact height tolerance
- Pitch angle tolerance
- Roll angle tolerance
- Yaw angle tolerance**

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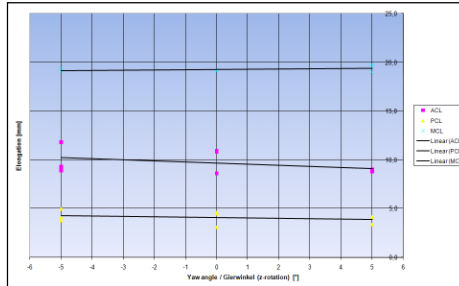
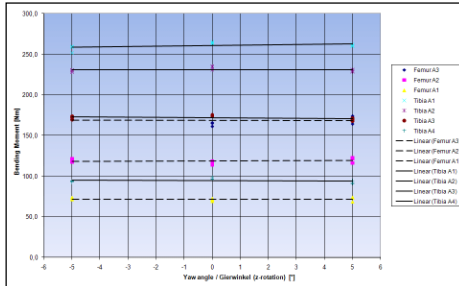
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Yaw angle tolerance (1)



- Current proposal: $0 \pm 5^\circ$ (vehicle tests / no requirement for inv. certification)
- Six Flex GT tests w/ variation of yaw angle (3^*-5° , 3^*+5°)
- Comparison with baseline tests



- Obvious influence of impactor yaw angle on ACL results only
- Anyway, in case ACL is foreseen as GTR injury criteria, corridor is proposed to be held as tight as possible for both certification and vehicle tests.

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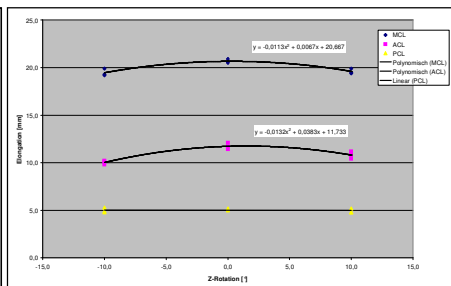
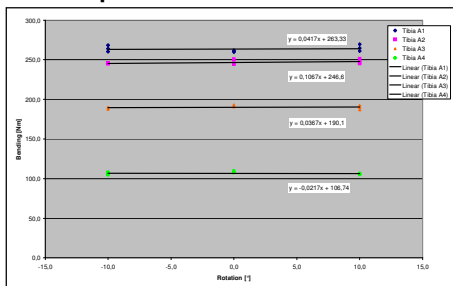
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Yaw angle tolerance (2)



- Six Flex GTR tests w/ variation of yaw angle (3^*-5° , 3^*+5°)
- Comparison with baseline tests



- Obvious influence of impactor yaw angle on ACL and MCL results
- Corridor is proposed to be held as tight as possible for both certification and vehicle tests:
Impactor yaw angle at the point of first contact = $0 \pm 2^\circ$

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Summary



Parameter	Proposed Tolerance for Inverse Certification Test	Proposed Tolerance for Vehicle Testing
Temperature	20 ± 2 °	20 ± 4 °
Impact Velocity	$11,1 \pm 0,2$ m/s	$11,1 \pm 0,2$ m/s
Impact Height	0 ± 2 mm	75 ± 8 mm
Pitch Angle	0 ± 2 °	0 ± 2 °
Roll Angle	0 ± 2 °	0 ± 2 °
Yaw Angle	0 ± 2 °	0 ± 2 °

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Thank you !

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