Review of Injury Criteria and Injury Thresholds for Flex-PLI
### Flex-GT Tentative Threshold Values

<table>
<thead>
<tr>
<th>Body regions</th>
<th>50% injury risk level of AM50 (tentative)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg (Tibia)</td>
<td>BM (312 - 350 Nm)</td>
<td>BM (312 Nm): Kerrigan et al., 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BM (350 Nm): INF GR/PS/82</td>
</tr>
<tr>
<td>Knee (MCL)</td>
<td>BA (18 - 20 deg)</td>
<td>BA (18 deg): Ivarsson et al., 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BA (20 deg): INF GR/PS/82</td>
</tr>
</tbody>
</table>

AM50: 50 percentile of American male
BM: Bending moment, BA: Bending angle, EL: Elongation, SD: Shearing displacement.

#### Convert: Human value >>> Flex-GT value

<table>
<thead>
<tr>
<th>Human value</th>
<th>Human Model</th>
<th>Flex-GT Model</th>
<th>Flex-GT Model</th>
<th>Flex-GT Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibia bending moment</td>
<td>H_{TBM}</td>
<td>HM_{TBM}</td>
<td>FGT_{TBM}</td>
<td>FGT_{TBM}</td>
</tr>
<tr>
<td></td>
<td>(Nm)</td>
<td>(Nm)</td>
<td>(Nm)</td>
<td>(Nm)</td>
</tr>
<tr>
<td></td>
<td>312</td>
<td>312</td>
<td>299</td>
<td>299</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>350</td>
<td>337</td>
<td>337</td>
</tr>
</tbody>
</table>

Assumption: $H_{TBM} = H_{TBM}$. $FGT_{TBM} = FGT_{TBM}$

$FGT_{TBM} = 0.9977 \times H_{TBM} - 12.325$ (from regression curve)

<table>
<thead>
<tr>
<th>Human value</th>
<th>Human Model</th>
<th>Human Model</th>
<th>Flex-GT model</th>
<th>Flex-GT model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee bending angle</td>
<td>H_{KBA}</td>
<td>HM_{KBA}</td>
<td>HM_{MCL}</td>
<td>FGT_{MCL}</td>
</tr>
<tr>
<td></td>
<td>(deg.)</td>
<td>(deg.)</td>
<td>(mm)</td>
<td>(mm)</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>18</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>17</td>
<td>20</td>
</tr>
</tbody>
</table>

Assumption: $H_{KBA} = H_{KBA}$. $FGT_{MCL} = FGT_{MCL}$

$HM_{MCL} = 0.835 \times H_{KBA}$ (from human model output)

$FGT_{MCL} = 0.6924 \times HM_{MCL} + 8.0156$ (from regression curve)
References
References (referred contents)


Injury Risk Curve for Mid-Leg


### References (referred contents)

- **Human value**

### Injury Risk Curve for Mid-Leg

**Tibia Bending Strength and Response**  
Nyquist G. W. et al, 1985 (SAE, Paper No. 851728)

<table>
<thead>
<tr>
<th>TestNo.</th>
<th>CadaverNo.</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Stature (m)</th>
<th>Body Mass (kg)</th>
<th>Impact Speed (m/s)</th>
<th>Direction of Loading</th>
<th>Peak Bending Moment at Midspan (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>118</td>
<td>458</td>
<td>M</td>
<td>54</td>
<td>1.82</td>
<td>68</td>
<td>3.5</td>
<td>LM</td>
<td>395</td>
</tr>
<tr>
<td>124</td>
<td>406</td>
<td>M</td>
<td>64</td>
<td>1.77</td>
<td>82</td>
<td>4.2</td>
<td>LM</td>
<td>287</td>
</tr>
<tr>
<td>126</td>
<td>375</td>
<td>M</td>
<td>58</td>
<td>1.74</td>
<td>73</td>
<td>4.2</td>
<td>LM</td>
<td>224</td>
</tr>
<tr>
<td>127</td>
<td>404</td>
<td>M</td>
<td>56</td>
<td>1.76</td>
<td>79</td>
<td>3.7</td>
<td>LM</td>
<td>237</td>
</tr>
<tr>
<td>129</td>
<td>395</td>
<td>M</td>
<td>57</td>
<td>1.78</td>
<td>99</td>
<td>3.7</td>
<td>LM</td>
<td>349</td>
</tr>
<tr>
<td>132</td>
<td>525</td>
<td>M</td>
<td>57</td>
<td>1.87</td>
<td>45</td>
<td>3.8</td>
<td>LM</td>
<td>264</td>
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<tr>
<td>147</td>
<td>400</td>
<td>M</td>
<td>57</td>
<td>1.78</td>
<td>84</td>
<td>2.9</td>
<td>LM</td>
<td>431</td>
</tr>
</tbody>
</table>

* The peak values were attenuated by 10 % by filtering (CFC 60) procedure.

**Proposed injury threshold for tibia bending: 350 Nm**

References (referred contents)

Injury Risk Curve for Knee (Bending)

RECONSIDERATION OF INJURY CRITERIA FOR PEDESTRIAN SUBSYSTEM LEGFORM TEST

- PROBLEMS OF RIGID LEGFORM IMPACTOR -

Konosu A. et al, 2001 (ESV, Paper No. 263)

Proposed injury threshold for Knee bending: 20 deg.

IHRA/PS/309
2) Knee injury risk curve for shearing

No injury risk curve is set by IHRA/PS because of its priority is low from the accident. IHRA/PS just described an example 10 mm from the Dr. Cesari’s computer simulation analysis.
Under the lateral or medial side impact, only ACL injured case is quite rare (3%). Most of all (97%) case accompany with other ligament injuries.
Fig. 8. Stages of the left knee injury (frontal view) in the mechanism of valgus flexion. (A) Avulsion of the medial collateral ligament; (B) avulsion of the anterior cruciate ligament; (C) avulsion of the posterior cruciate ligament. A → C increasing compression of the lateral tibial and femoral condyles.