Informal Group on GTR9 Phase2 (IG GTR9-PH2)  
1st Meeting  
Technical Discussion – Benefit  

December 1-2, 2011  
Japan Automobile Standards Internationalization Center (JASIC)
Outline

1. Anticipated Factors for Enhanced Injury Mitigation
2. Estimation of Cost Reduction due to Tibia Fracture Mitigation
3. Summary
1. Anticipated Factors for Enhanced Injury Mitigation
- Improved Biofidelity -

4. Comparison of Component Responses
- Tibia Bending -

**Flex-PLI** tibia response characteristics are much closer to those of human compared to TRL legform.

5. Correlation of Assembly Impact Responses
- CAE Correlation Study -
 Correlation of Tibia Injury Measures

- No correlation between TRL legform upper tibia acceleration and human tibia bending moment
- Good correlation between Flex-PLI and human tibia bending moment


4. Comparison of Component Responses
- Knee Bending -

- Flex-PLI knee joint is stiffer than that of human
- Flex-PLI stiffness is much more comparable to human stiffness than TRL legform

5. Correlation of Assembly Impact Responses
- CAE Correlation Study -
 Correlation of ACL Injury Measures

- No correlation between TRL legform knee shear displacement and human ACL elongation
- Good correlation between Flex-PLI and human ACL elongation
1. Anticipated Factors for Enhanced Injury Mitigation

- Enhanced Injury Assessment Capabilities -

- Wider coverage of tibia fracture
- Use of bending moment that best describes human tibia fracture

- Flex-PLI ligaments elongate due to combined knee loading
- Use of ligament elongation provides better correlation with human injuries
1. Anticipated Factors for Enhanced Injury Mitigation

- Otte et al. (2007) -

CHARACTERISTICS ON FRACTURES OF TIBIA AND FIBULA IN CAR IMPACTS TO PEDESTRIANS – INFLUENCES OF CAR BUMPER HEIGHT AND SHAPE

Otte, D.*; Haasper, C. **
* Accident Research Unit
** Trauma Department
Medical University Hanover, Germany

ABSTRACT
This study deals with the analysis of lower leg fractures in pedestrians after collisions with passenger cars and examines to what extent the shape and location of the fractures in the lower leg changed, following alterations in the shape and height of bumpers. It can be assumed that the bumpers changed in form and effective impact height, not least due to the realization of the developments of vehicle safety tests as in the context of the European Union Directive 2003/102/EC. In addition, consumer protection tests, EuroNCAP, accomplished a change of the injury situation.

For the study, traffic accidents from GIDAS (German in-Depth-Accident Study) were selected, which had been documented in the years 1995 to 2004 by scientific teams in Hannover and Dresden areas and for which there is detailed information regarding injury patterns and collision speeds. The

- 1995 – 2004 GIDAS data
- 143 pedestrians with leg fractures (tibia/fibula) documented by X-rays

1. Anticipated Factors for Enhanced Injury Mitigation

- Otte et al. (2007) -

If the heights of the fractures are correlated to the effective dynamic heights of the bumpers, it turns out that 80% of all fractures are located between 19 and 46 cm, whereas 80% of the impact forces are transferred at heights of 32 to 44 cm of the lower leg (Figure 4). Thus the cause of the fractures is frequently located above the fracture itself. Fracture height and bumper height were only identical in 17.5% of the cases, in 47.5% fracture was above the bumper and 35% fracture below the bumper.

- Fracture location was identical to the bumper height only in 17.5 % of the cases
- 82.5% of fractures are presumed to be due to indirect loading

1. Anticipated Factors for Enhanced Injury Mitigation
- Japanese In-depth Accident Data (ITARDA) -

Most significant improvement is with leg fracture mitigation.
2. Estimation of Cost Reduction due to Tibia Fracture Mitigation

- Estimated Reduction in Annual Medical Cost (US, JPN) -

Number of Pedestrians Sustaining Tibia Fracture by MAIS
PCDS, age > 15

<table>
<thead>
<tr>
<th>MAIS</th>
<th>Total</th>
<th>with Tibia Fracture</th>
<th>without Tibia Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>165</td>
<td>0</td>
<td>165</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>49</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Fatality Ratio by MAIS

<table>
<thead>
<tr>
<th>MAIS</th>
<th>Fatality Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.0%</td>
</tr>
<tr>
<td>3</td>
<td>5.3%</td>
</tr>
<tr>
<td>4</td>
<td>22.5%</td>
</tr>
<tr>
<td>5</td>
<td>47.6%</td>
</tr>
<tr>
<td>6</td>
<td>99.0%</td>
</tr>
</tbody>
</table>


Percentage of Tibia Fracture by Injury Severity

<table>
<thead>
<tr>
<th>Injury Severity</th>
<th>With Tibia Fracture (%)</th>
<th>Without Tibia Fracture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>32.7%</td>
<td>67.3%</td>
</tr>
<tr>
<td>Severe</td>
<td>22.6%</td>
<td>77.4%</td>
</tr>
<tr>
<td>Minor</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 14. Probability of Fatality vs. Maximum Known AIS
2. Estimation of Cost Reduction due to Tibia Fracture Mitigation

- Estimated Reduction in Annual Medical Cost (US, JPN) -

### Percentage of Tibia Fracture by Injury Severity

<table>
<thead>
<tr>
<th>Injury Severity</th>
<th>With Tibia Fracture (%)</th>
<th>Without Tibia Fracture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>32.7%</td>
<td>67.3%</td>
</tr>
<tr>
<td>Severe</td>
<td>22.6%</td>
<td>77.4%</td>
</tr>
<tr>
<td>Minor</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

### Annual Medical Cost due to Tibia Fracture

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>$171,901,940</td>
</tr>
<tr>
<td>JPN</td>
<td>$88,010,679</td>
</tr>
</tbody>
</table>

### Weighed Cost For Tibia Fracture

<table>
<thead>
<tr>
<th>Tibia AIS</th>
<th>count</th>
<th>Weighed Cost For Tibia Fracture = $44,684 ($1 = ¥80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

### Annual Medical Cost Reduction from Tibia Fracture Mitigation

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>$99,273,370</td>
</tr>
<tr>
<td>JPN</td>
<td>$50,826,167</td>
</tr>
</tbody>
</table>

- Estimated Reduction in Annual Medical Cost (US, JPN) -

- (
  - Coverage increase
  - (Protection Level)

- US Fatal : FARS
- US Non-fatal : NASS-PCDS (Weighed)
- JPN : ITARDA
3. Summary

- The Flex-PLI provides improved biofidelity of the tibia and knee at both assembly and component levels.
- Accident data show that tibia fracture is most frequent in pedestrian severe (AIS 2+) injuries.
- Most significant factor that would contribute to injury mitigation is enhanced biofidelity of the tibia and much wider coverage of injury measurements over the tibia.
- Additional annual medical cost reduction due to tibia fracture mitigation by introducing the Flex-PLI was estimated approximately $100M in the US and $50M in Japan relative to the use of TRL legform.
References

- Otte, D., Haasper, C., Characteristics on Fractures of Tibia and Fibula in Car Impacts to Pedestrians – Influences of Car Bumper Height and Shape, IRCOBI Conference (2007)


Thank you for your attention