JAPAN Research Status for Bio-RID II Injury Parameters on Head Restraints GTR

September ’05

JAPAN MLIT
Proper Evaluation for Reduction of the Risk of Whiplash Injury

Proper Evaluation for Reduction of the Risk of Whiplash Injury has been deduced from the researches done by Ono et. al. from ’96 to ’03 and also from the many researches published in the past.
Spinal Movement Due to Impact

For Whiplash Injury Mechanism Based on Human Volunteer Test
Cineradiography

Lateral view of subject

Test Set-up

Max. speed: 9 km/h

Inclination 10 degrees

Shock absorber

Subject

Seat

Head Accelerometers

Upper sternum

7/1300

12th rib

Iliac crest
Whole Spine Motion During Rear Impact
Rear-End Impact

Female, Velocity: 6 km/h
Head·T1·Pelvis accelerations
EMG(SCM, PVM, VMRA, M_OEA, M_LD)
Axial force

Bending moment

Facet impingement

C5/6 open book-like motion

Initial flexion S-shape curvature full extension

Initial flexion  S-shape  Full extension
Whiplash Injury
Not only neck motion
The whole spine motion should be considered

S-shape deformation
(Vertical, Horizontal Motion)

Cervical spine motion

Straightening of spine
Ramping-up

Current Evaluation (Inadequate)
Upper neck
1) Head rotation
2) Upper neck moment

Neck angle
Parameters to be included

Lower neck
1) Axial, shear forces
2) Neck angle wrt T1

New index ; NIC ?
To be proposed as a new neck injury indications

Proper Evaluation for Reduction of the Risk of Whiplash Injury
### Current Proposed Evaluation Parameters

#### Proposed Injury Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Proposer</th>
<th>Year</th>
<th>Formula or Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIC</td>
<td>Bostrom</td>
<td>‘96</td>
<td>$NIC = a_{nc} - 0.2 + v_{nc}^2 &lt; 15m^2/s^2$</td>
</tr>
<tr>
<td>IV-NIC</td>
<td>Panjabi</td>
<td>‘99</td>
<td>$IV-NIC_i = \frac{\theta_{\text{trauma}, i}}{\theta_{\text{physiological}, i}}$</td>
</tr>
</tbody>
</table>

**Velocity of T1 (Rebound)**

- **Muser** '00
  - (1) $e_i$: Approximate ratio of kinematic energy before and after the contact of head and head restraint.
  - (2) $\Delta t$: Time difference between zero points of head velocity and T1 velocity.
  - (3) $v_{ch}$: T1 velocity relative to the sled when the rearward displacement of the head relative to T1 is maximum.
  - (4) $v_{rel+}$: Peak relative velocity between head and T1 along x-axis after contacting the head restraint.
  - (5) $v_{head+}$, $v_{T1+}$: Velocity of head and T1 before the seat belt starts restraining the occupant.
  - (6) Dynamic and residual deflections of seatback

- **Viano** '01
  - $Nd_{distractive} = \frac{Z_{OC-T1}}{15mm}$
  - $Nd_{extensive} = \frac{\theta_{OC-T1}}{25^\circ}$
  - $Nd_{shear} = \frac{X_{OC-T1}}{35mm}$

- **Schmitt** '02
  - $N_{\text{shear}}(t) = \frac{F_x(t)}{M_{se}} + \frac{M_{se}}{M_{se}}$

- **Heitplatz** '03
  - $LNL - \text{index}(t) = \frac{M_{\text{elongated}}(t) + M_{\text{transverse}}(t)}{C_{\text{elongation}}} + \frac{F_{\text{transverse}}(t)}{C_{\text{shear}}} + \frac{F_{\text{elongation}}(t)}{C_{\text{elongation}}}$

- **Kullgren** '03
  - $MIX = \left( \frac{NIC_{\text{max}}}{NIC_{\text{max}}} \right) + \left( \frac{N_{\text{shear}}}{N_{\text{shear}}} \right)$

- **Muñoz** '05
  - $WIC = M_{NIC} - M_{\text{shear}}$

**Conclusion**: This proper evaluation of S-shape deformation of cervical spine is more reliable for assessment on the upper part (Occipital Condyle) and the lower part (T1) of cervical spine.
Time phase is limited within the phase of neck s-shape. The above tentative proposed evaluation parameters are induced from Japan based on the research of the biomechanical responses on human volunteer and relevant tests.
Thank you for your attention!!