Whiplash Injury Research – History and Current Research in Biomechanics

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Research strategy – Crash Safety

- Epidemiology
- Accident analysis
- Biological models
- Impact biomechanics
- Theoretical and Physical Models
- Countermeasures
- Test procedures
- Injury mechanisms
- Injury criteria
- Threshold levels
Models

Biological    Mechanical    Mathematical
Motion pattern

Lab seat
\[ \Delta v = 7.6 \text{ km/h} \]
Peak acceleration 3.2 g
Motion pattern

• Rigid seat
• $\Delta v = 9.3$ km/h
• Peak acceleration $3.4$ g
Conclusions - Motion Pattern

• Torso ramps up the seatback and the thoracic spine is straightened
  – T1 upward displacement
  – T1 rearward rotation

• Neck exhibits complex motions
  – Initial flexion
  – S-shape motion; excessive stretch of anterior and posterior tissues
  – Extension

• Torso and head forward rebound
Dummy development

BioRID and Human

Hybrid III and Human
BioRID II
Comparison of dynamic performance

- Tested:
  - BioRID II
  - Hybrid III
  - Volunteers
- Thor
- RID II and III
T1 angular displacements

- Volunteer corridor
- BioRID II
- Hybrid III

Rigid seat

Flexible seat

Standard seat

Angle (deg)

Time (ms)
Abnormal vertebra motions

Excessive neck loads

Local hyper-extension/flexion

Pressure pulses spinal canal

Zygapophysial joint

Disc

Muscle

Ligament

Artery

CNS

Dorsal nerve-root ganglion

Symptoms

1 Bogduk and April (1993)
2 Bogduk et al. 1998b
3 Brault et al. 2000
4 Clemens and Burow 1972
5 Davis et al. 1991
6 Dvorak et al. 1987
7 Harriton 1989
8 Kischka et al. 1991
9 Kaneoka et al. 1997
10 Kaneoka et al. 1999
11 Knibestöl et al. 1990
12 Macnab 1982
13 Ono et al. 1997
14 Panjabi et al. 1998a
15 Svensson et al. 1993c
16 Watkinson et al. 1991
17 Wickström et al. 1967
18 Yoganandan et al. 1998
19 Yuan et al. 1998
20 Örtengren et al. 1996
Retraction  Extension

Phase 1  Phase 2  Phase 3

Skull pressure  Spine pressure T1  Spine pressure C4

Pressure (mmHg)

Time (ms)
Abnormal vertebra motions

Excessive neck loads

Local hyper-extension/flexion

Pressure pulses spinal canal

Vertebral artery

Brain, stem and cord

Dorsal nerve-root ganglion

Zygapophysial joint

Disc

Muscle

Ligament

Symptoms

Reconstruction of cases
Reconstruction

• Few car models with rear and frontal crash pulse data
• Un-instrumented occupants
• Uncertain pre-collision posture
• Currently only model of the average male available
IMPACTS OF NECK INJURIES RESEARCH AT CHALMERS UNIVERSITY OF TECHNOLOGY

Summary

Knut Sandberg Eriksen & Arild Hervik et al.

Summary of VINNOVA Analysis VA 2004:07
Conclusions

• Long tradition to work in various industrial and multidisciplinary consortia

• Combining basic and applied research aiming at advanced products
  – The whiplash research started -85 and has generated 600M€ (VINNOVA evaluation) for the society and the Swedish automotive industry
Thank You for your attention!