

The Effects of Seatback Reclined Positions of Occupants in Motor Vehicles Collisions

Seattle CIREN Team (Bulger, Dissanaiké, Kaufman, Mack)

University of Washington

Harborview Injury Prevention and Research Center

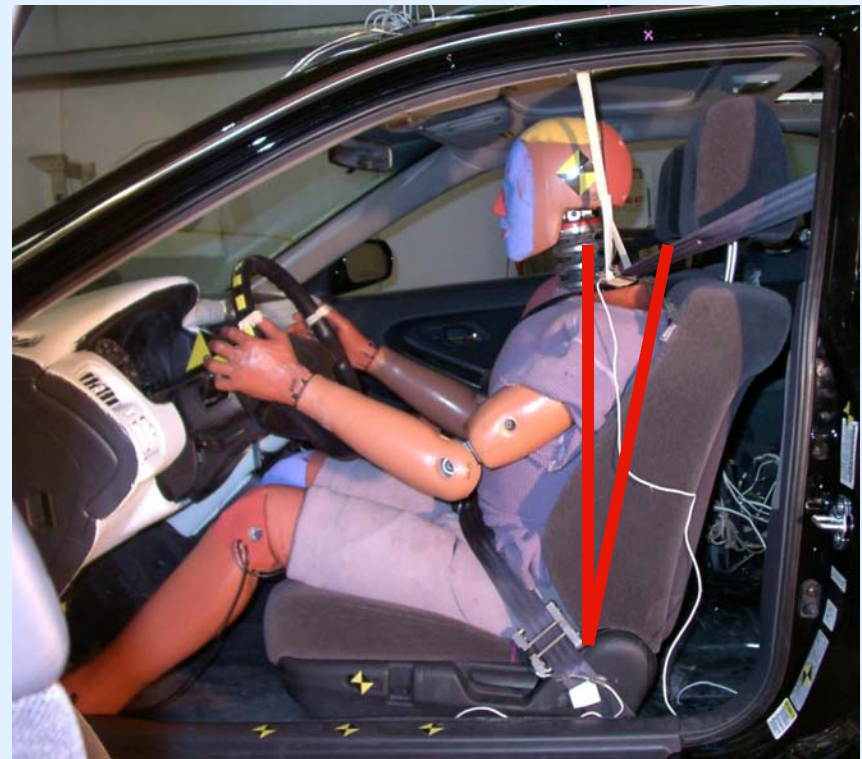


Background

- Motor vehicle crashes (MVC) are leading cause of trauma-related death in US each year
- Multiple factors determine outcome: Vehicle type, Delta-V, PDOF, seat belt use and airbag deployment
- Occupant factors such as height and weight also impact outcome
- Seat recline position has not been evaluated

Crash safety testing

- Performed by NHTSA and IIHS
- Test vehicles at different speeds and different body habitus of crash test dummies
- Standard driving seatback position used within 12 degrees of vertical



However..

Many occupants travel with
their seats reclined

Study Question:

Does reclining your seat impact your outcome from a motor vehicle crash?

Methods:

- Two components:
- 1. Detailed case review using Crash Injury Research Engineering Network (CIREN)
- 2. Outcomes analysis using NHTSA sponsored National Automotive Sampling System Crashworthiness Data Set (NASS/CDS)

Phase 1: CIREN Case Reviews

- Front seat occupants
- Case occupants documented in fully reclined seatback position by crash investigations or interviewee

Reclined CIREN cases, n=11

Age	32.4 (16 – 75) years
Sex	6 men, 5 women
Occupant Position	3 drivers, 8 passengers
Weight	85.3 (57 – 122) kg
Height	172.1 (150 – 185) cm
Delta V	47.4 (24 – 68) kmph
Frontal impact	8

CIREN case summary continued

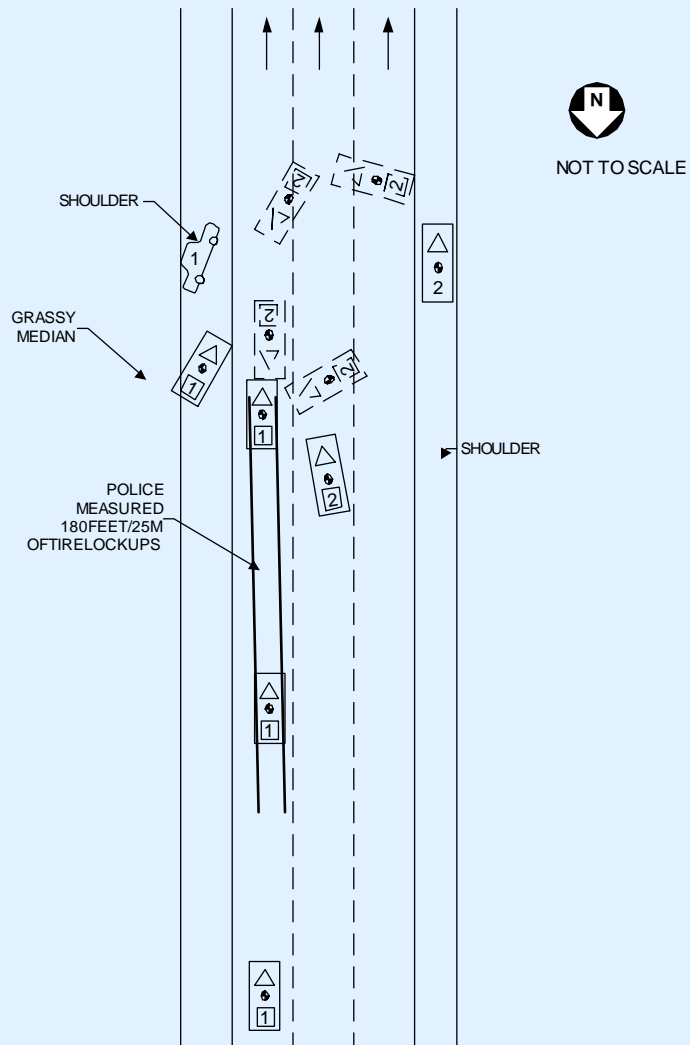
Seatbelt used	6 (54.5%)
Airbag deployed	6 (54.5%)
ISS	27.8 (2 – 75)
Mortality	3 (27.3%)

Seatback Fully Reclined

CIREN Case Reviews

Seatback Recline

CIREN Case Review 1 – Scene



Head-on

Full frontal crash

Speed Limit

70mph/112kmph

Seatback Recline CIREN Case Review 1 – Vehicle



2003 Compact 4 door sedan

PDOF – 12 o'clock

Delta V = 44kmph/ 27 mph (smash missing run)

Seatback Recline

Case Review 1 – Case Occupant



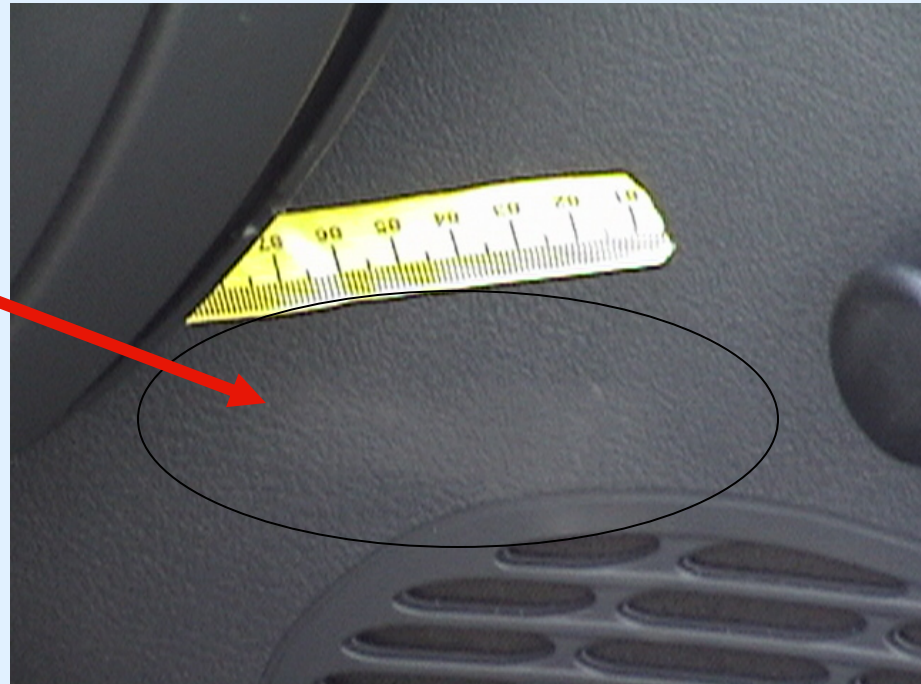
20's yr. – Female

Lap/shoulder & Air bag

Fully reclined seatback
position and sleeping

Seatback Recline

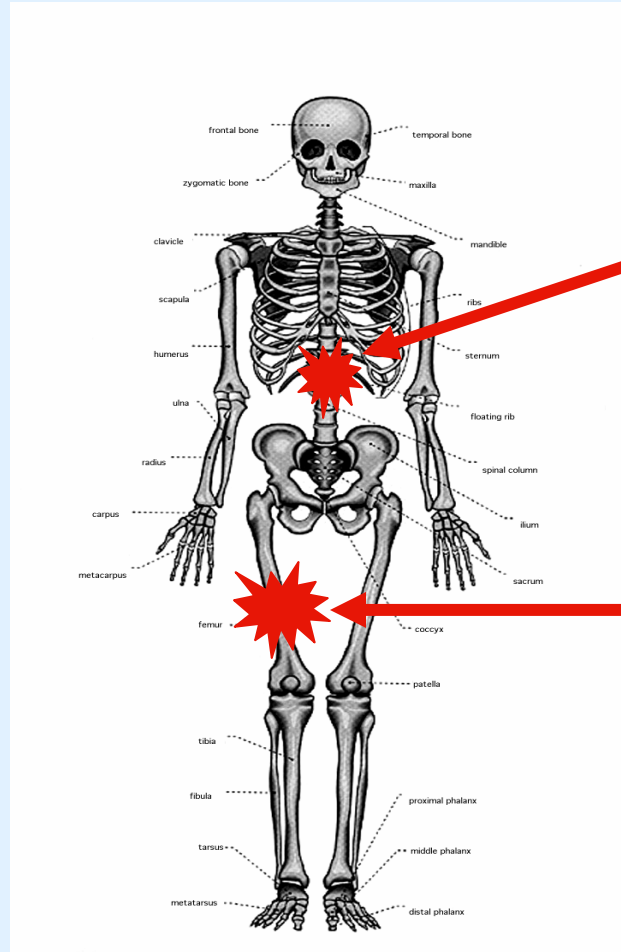
CIREN Case Review 1 – Contacts



R knee/Leg contact
scuff to door panel

Seatback Recline

CIREN Case Review 1 – Injuries

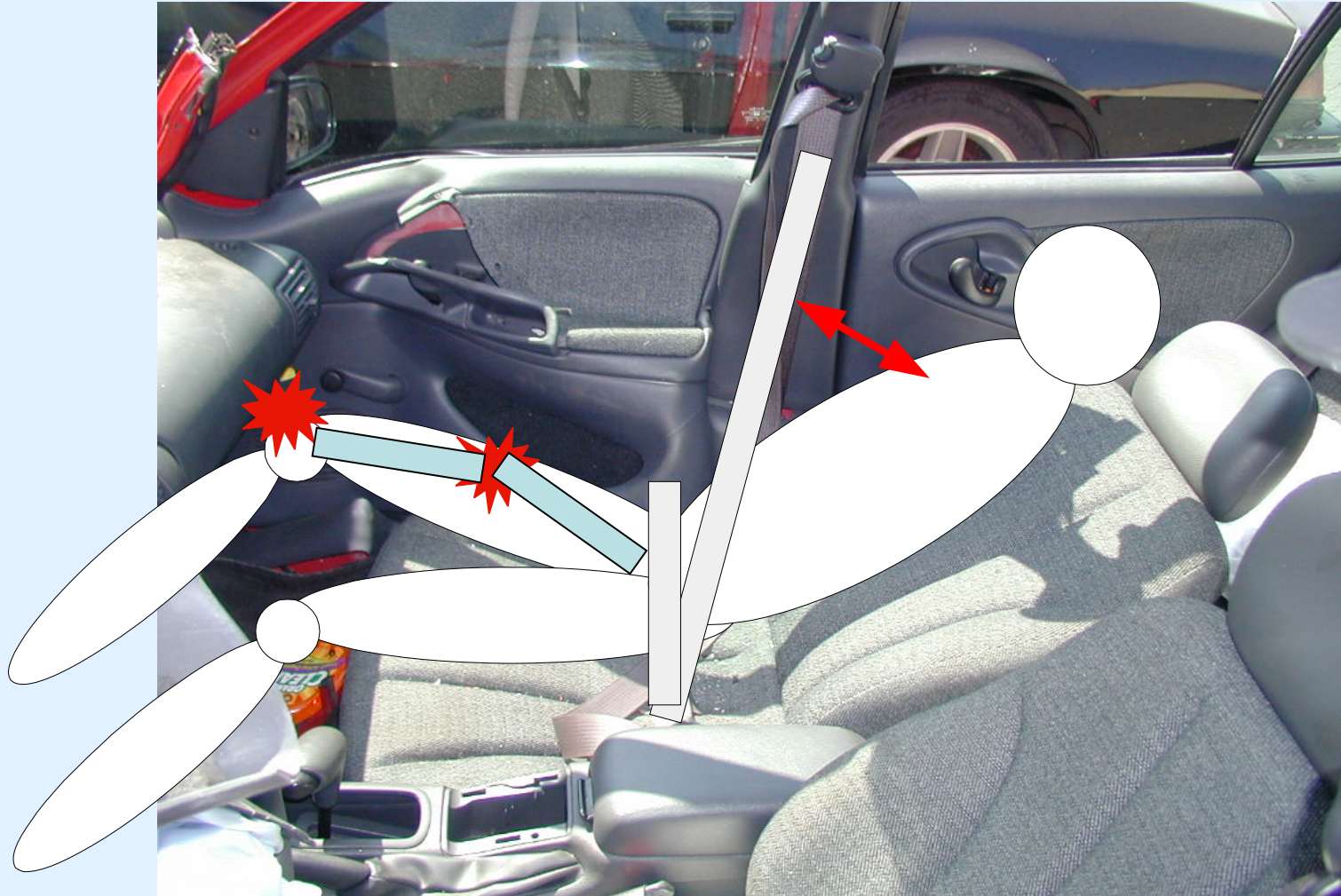


AIS 3
T-Spine

AIS 3
Lower Extremity

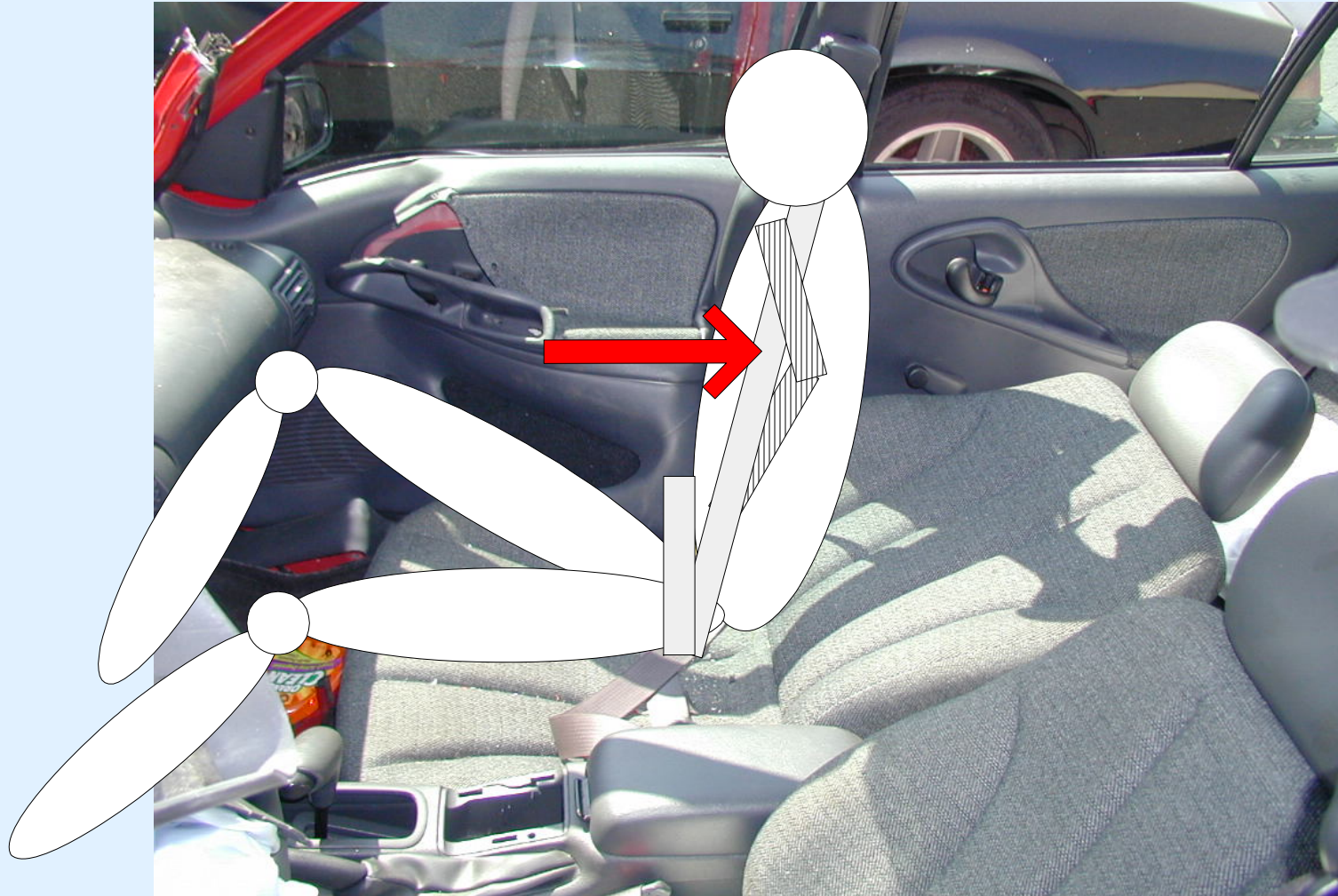
Seatback Recline

Case Review 1 – Occupant Kinematics



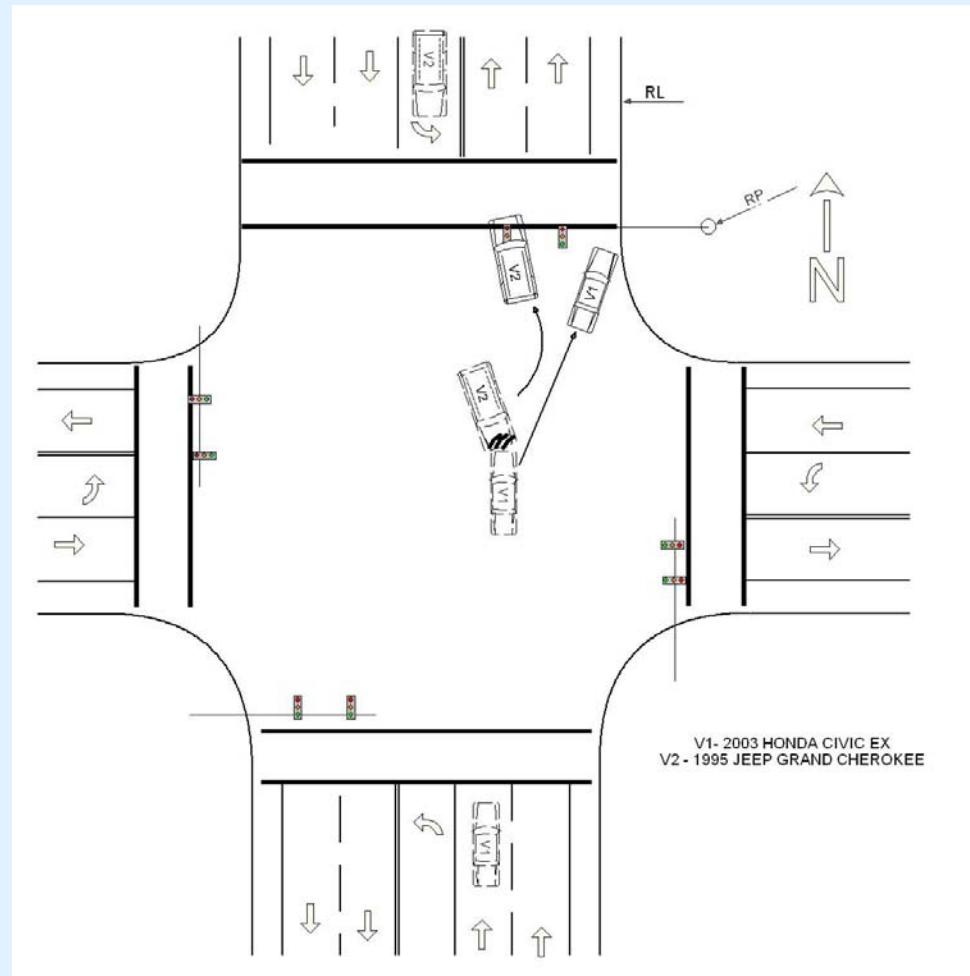
Seatback Recline

Case Review 1 – Occupant Kinematics



Seatback Recline

CIREN Case Review 2 – Scene



Seatback Recline

CIREN Case Review 2 – Case Vehicle



2003 Compact Sedan 2-door

PDOF - 12 o'clock

Reconstruction

Delta V = 24mph/38kmph

Seatback Recline

Case Review 2 – Case Occupant



Driver

Teenager – Male

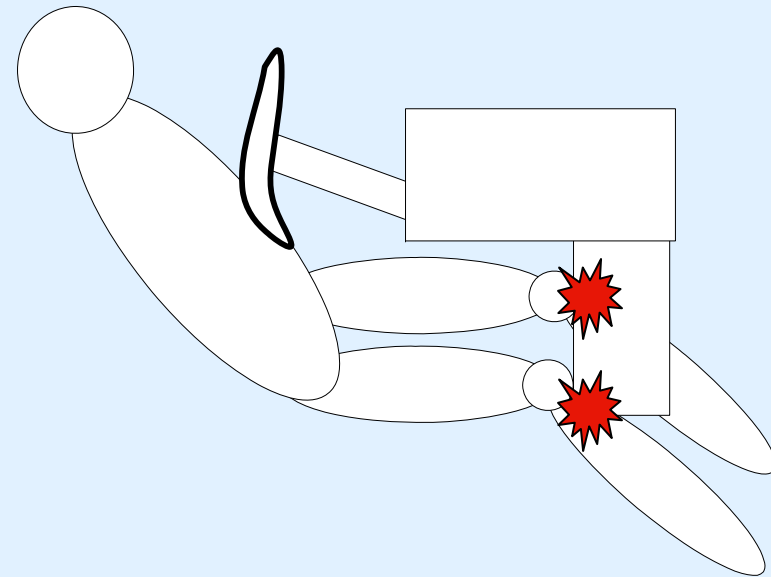
Frontal steering
column air bag
deployment

No manual seat belt
use

Seatback full recline

Seatback Recline

Case Review 2 – Occupant Kinematics



Bilateral knee bolster contacts

Deformed Steering Rim

Complete collapse steering
column

Seatback Recline Case Review 2 – Contacts

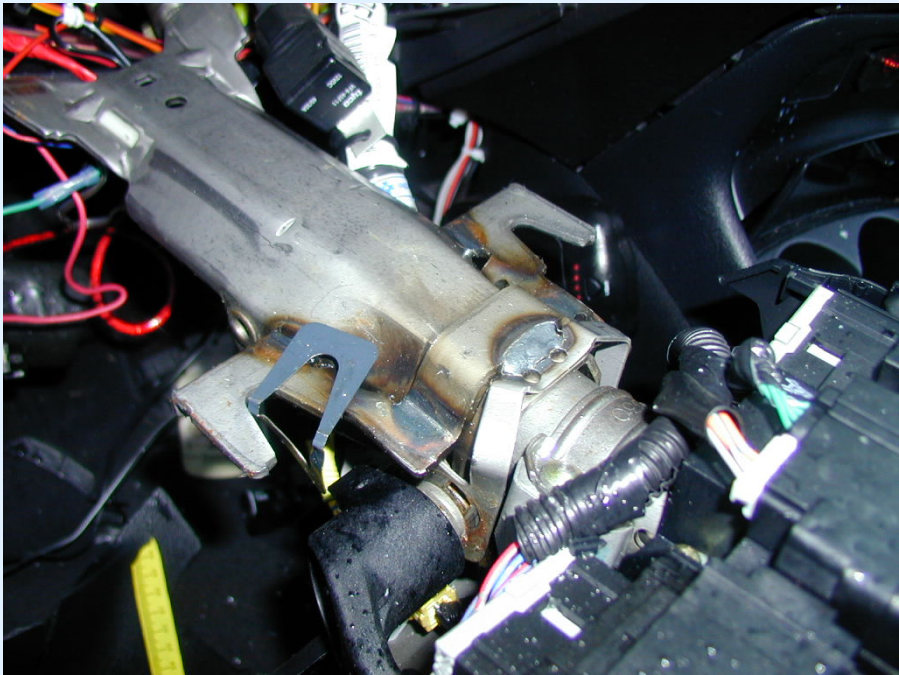


Steering Rim Deformation

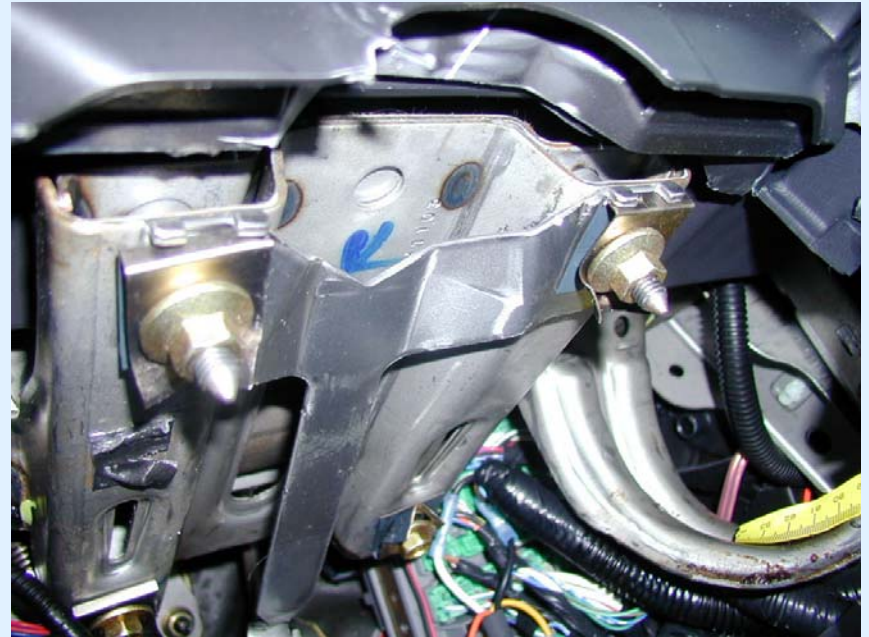


Complete Steering Column
Collapse

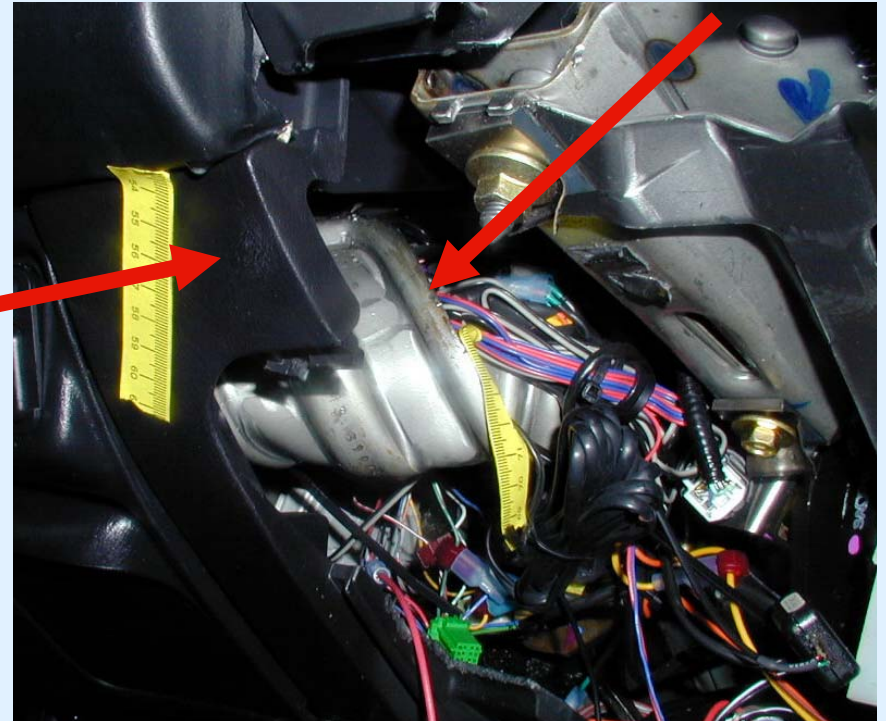
Seatback Recline Case Review 2 – Contacts



Shear Capsules



Seatback Recline Case Review 2 – Contacts



Left knee contact

Scuffed cover, Deformed Bolster

Seatback Recline Case Review 2 – Contacts



Right knee contact to bolster

Evidence: skin, fabric, hair

Seatback Recline Case Review 2 – Contacts



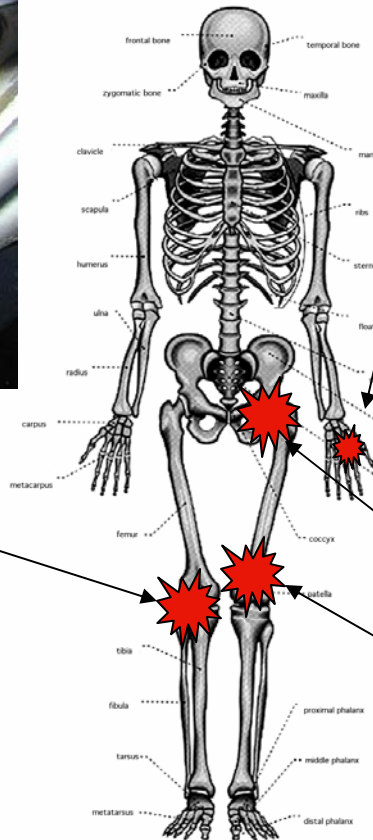
Left hand contact with intrusion of
windshield reinforced by exterior hood



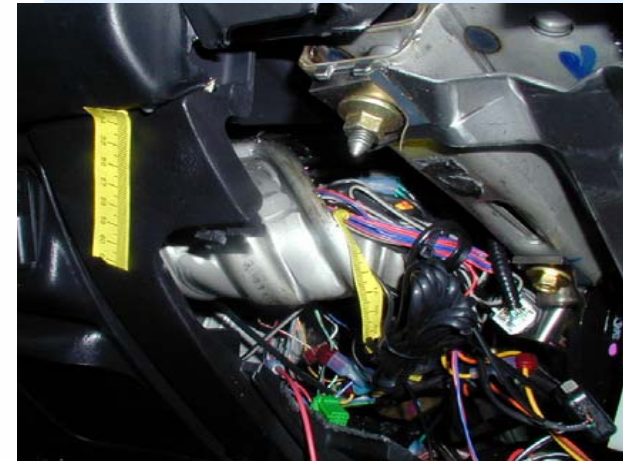
Seatback Recline Case Review 2 – Injuries



AIS 3 – Lower
Extremity



AIS 2 – Hand

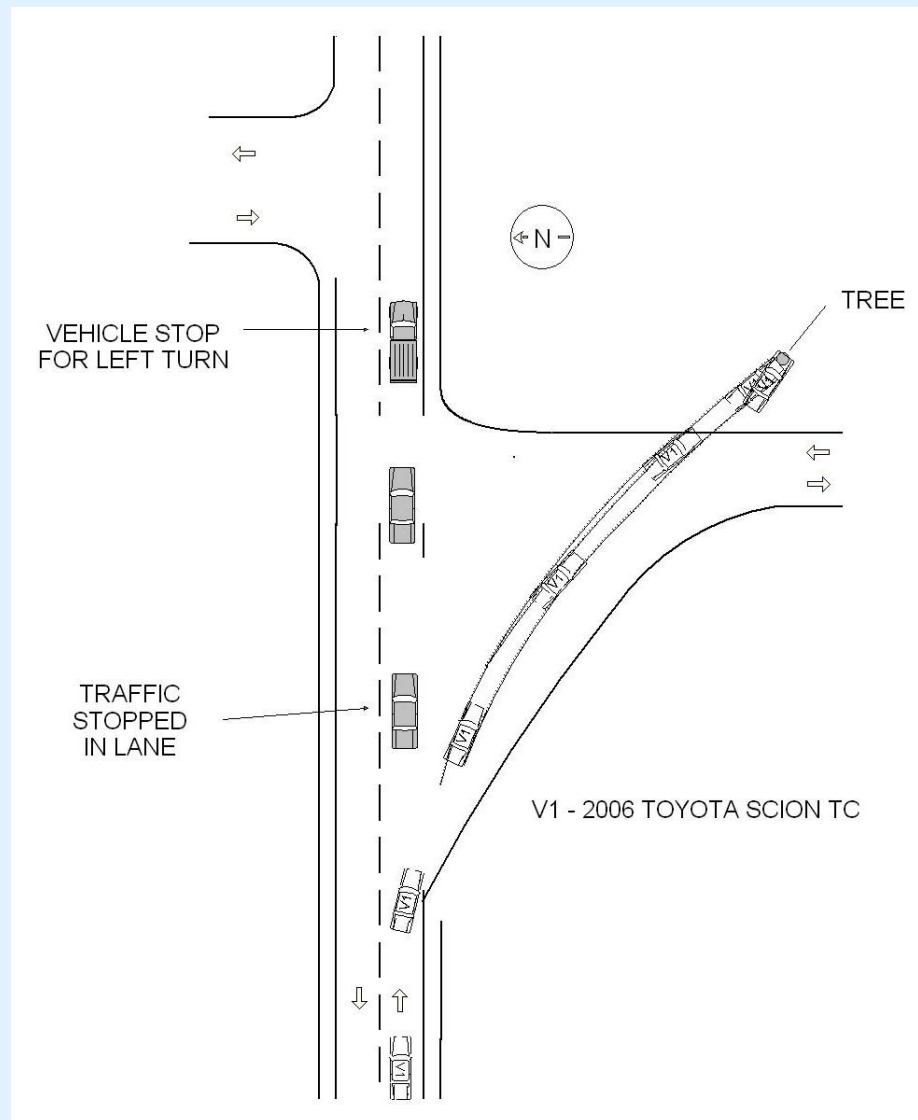


AIS 2 -Hip

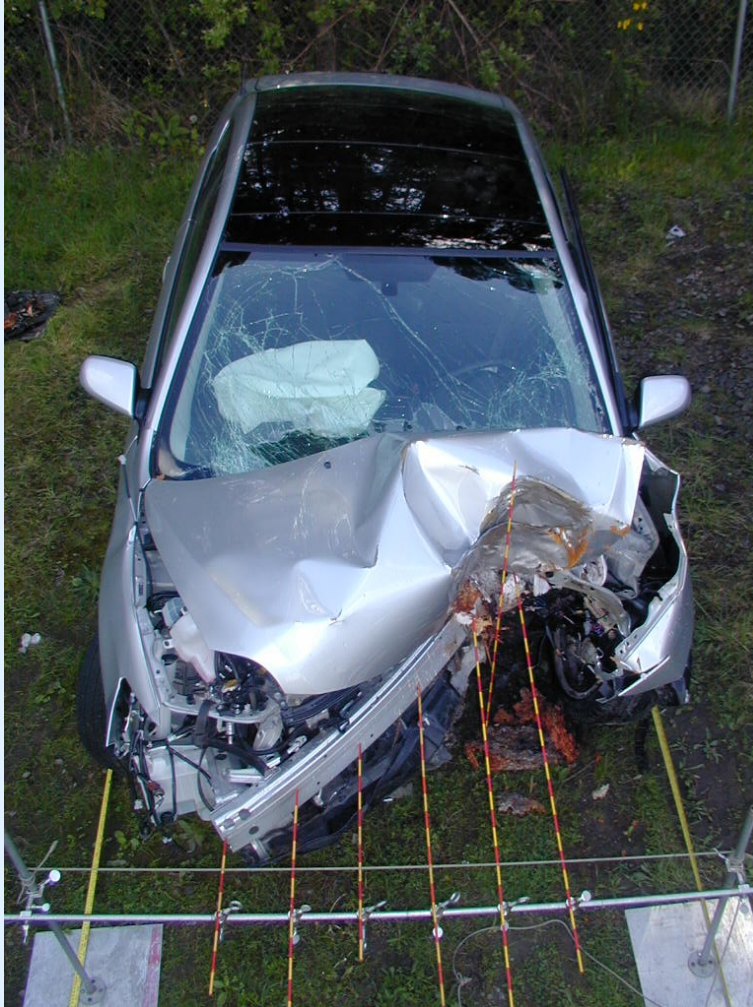
AIS 3 –Lower Extremity

Seatback Recline

CIREN Case Review 3 – Scene



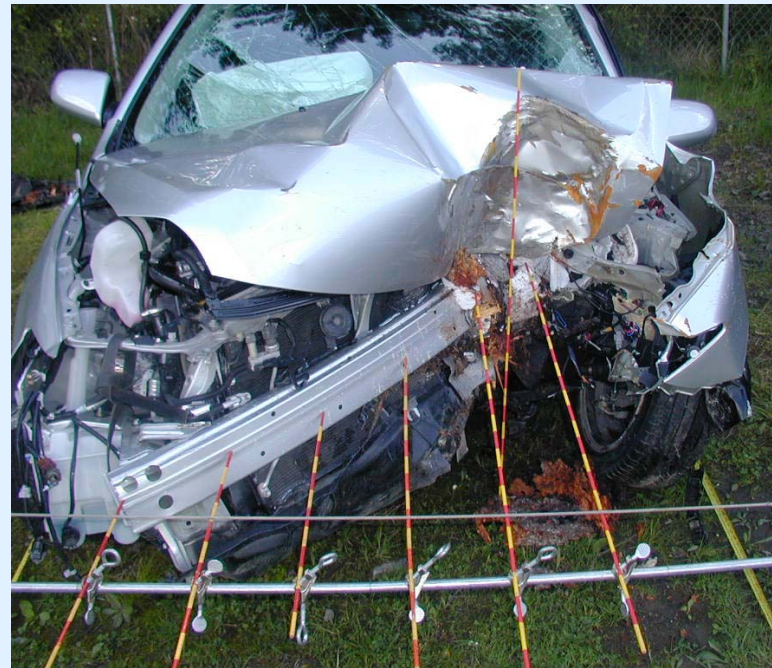
Seatback Recline Case Review 2 – Case Vehicle



2006 Compact - 2HB

12 o'clock PDOF

Delta V = 30 mph / 48 kmph



Seatback Recline

CIREN Case Review 3 – Driver



Elderly – Male

Seatback Upright Position

Manual Lap/Shoulder belt
w/ Pretensioner

Air bag Deployments

- Steering Column

- Knee Bolster

Seatback Recline CIREN Case Review 3 – Driver



Safety belt usage evidence at latch plate
and pillar point

Seatback Recline CIREN Case Review 3 – Driver



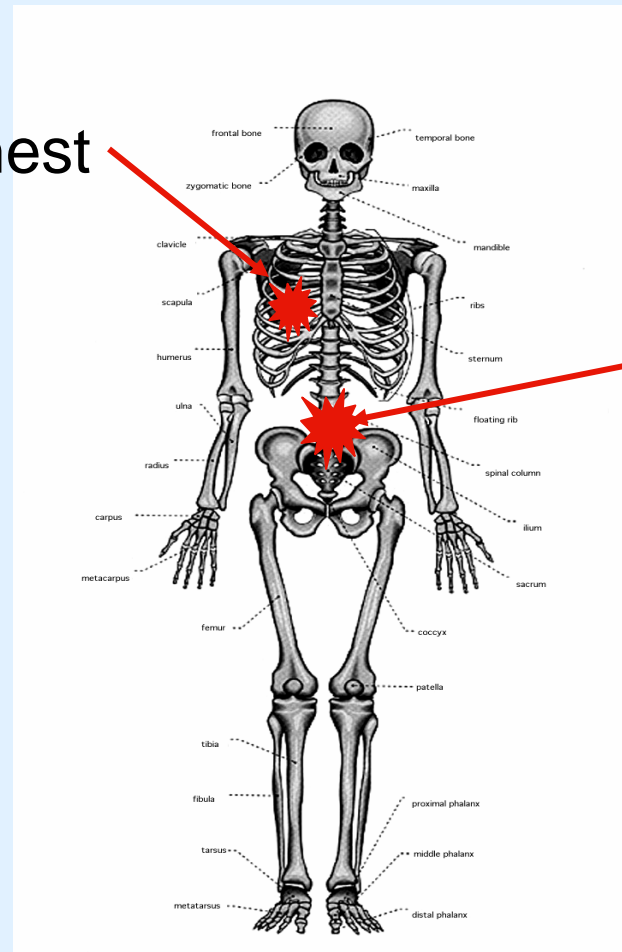
Air bag
Deployments



Seatback Recline

Case Review 3 – Driver Injuries

AIS 2 – Chest



AIS 3
L-spine

Seatback Recline

Case Review 3 – Case Occupant



Elderly – Female

Fully reclined
seatback

Manual lap/shoulder
w/pretensioner

Instrument panel air
bag deployment

Seatback Recline Case Review 3 – Contacts



Left and Right Knee contacts

Seatback Recline Case Review 3 – Contacts



Left and Right Knee contacts

Seatback Recline Case Review 3 – Safety Belt



Safety belt latch plate
and webbing

Seatback Recline Case Review 3 – Safety Belt



Seatback Recline Case Review 3 – Safety belt



Seatback Recline Case Review 3 – Injuries

AIS 6 C-spine

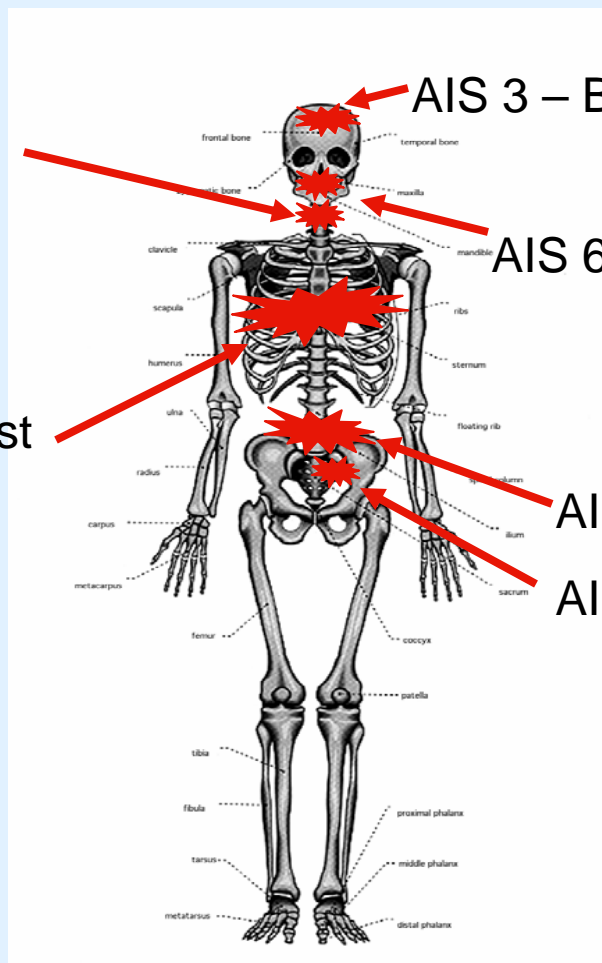
AIS 4 – Chest

AIS 3 – Brain

AIS 6 - Brain

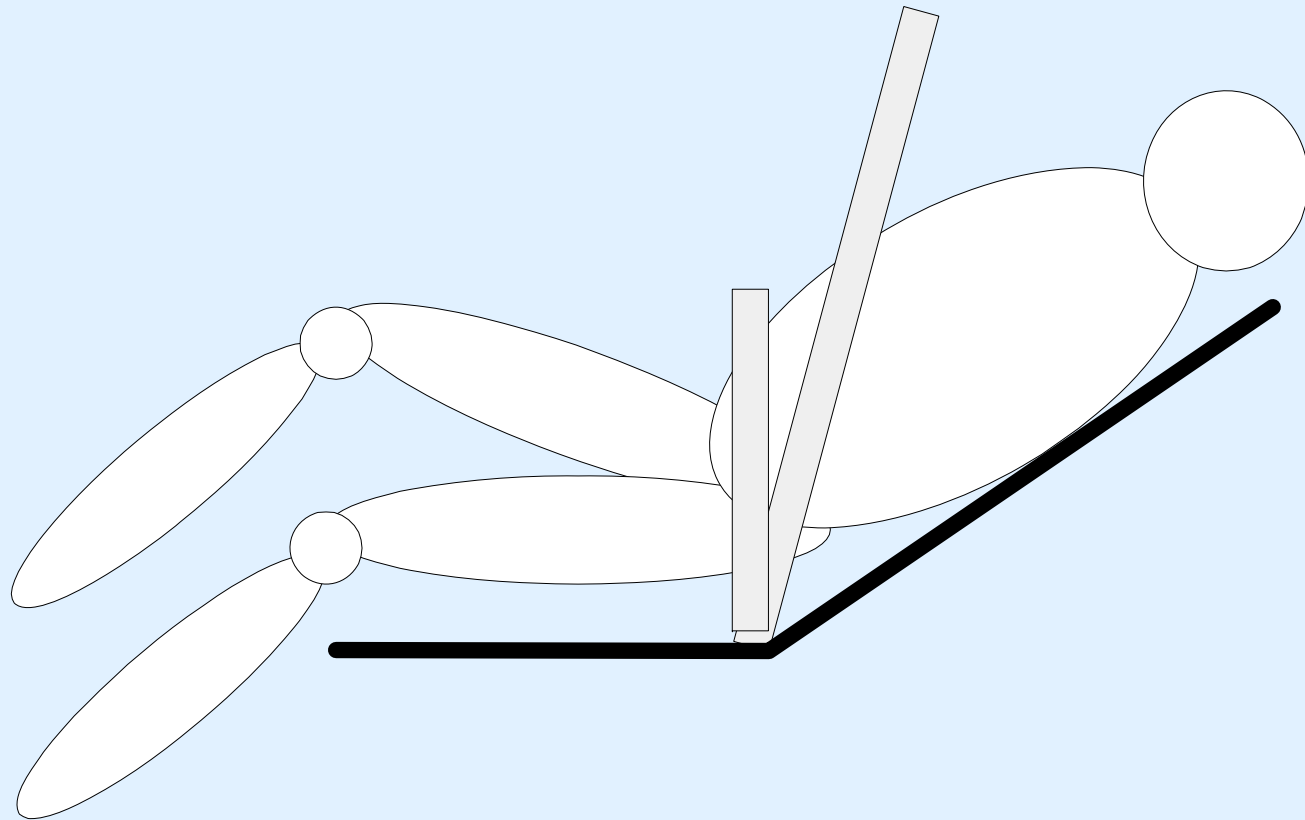
AIS 3 – Abdomen

AIS 3 – Pelvis



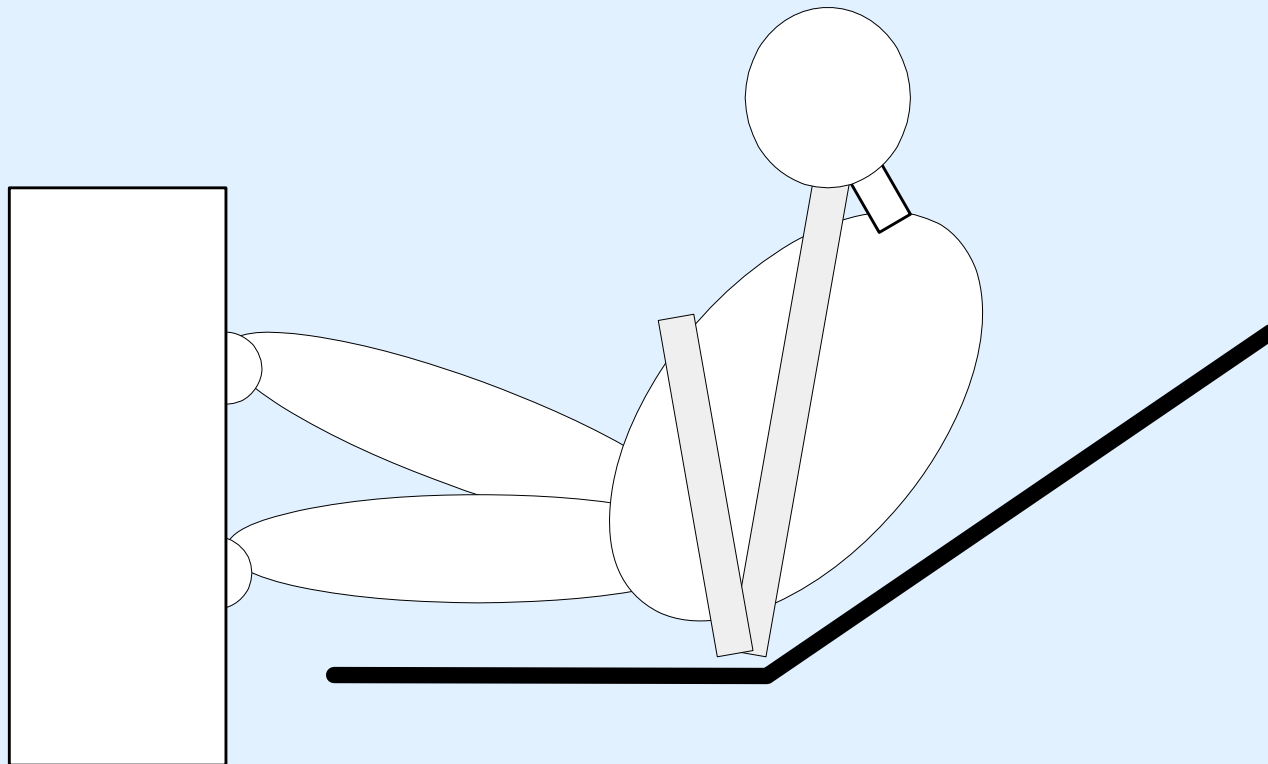
Seatback Recline

Case Review 3 – Occupant Kinematics



Seatback Recline

Case Review 3 – Occupant Kinematics



Mechanisms in fully recline seatback CIREN case reviews

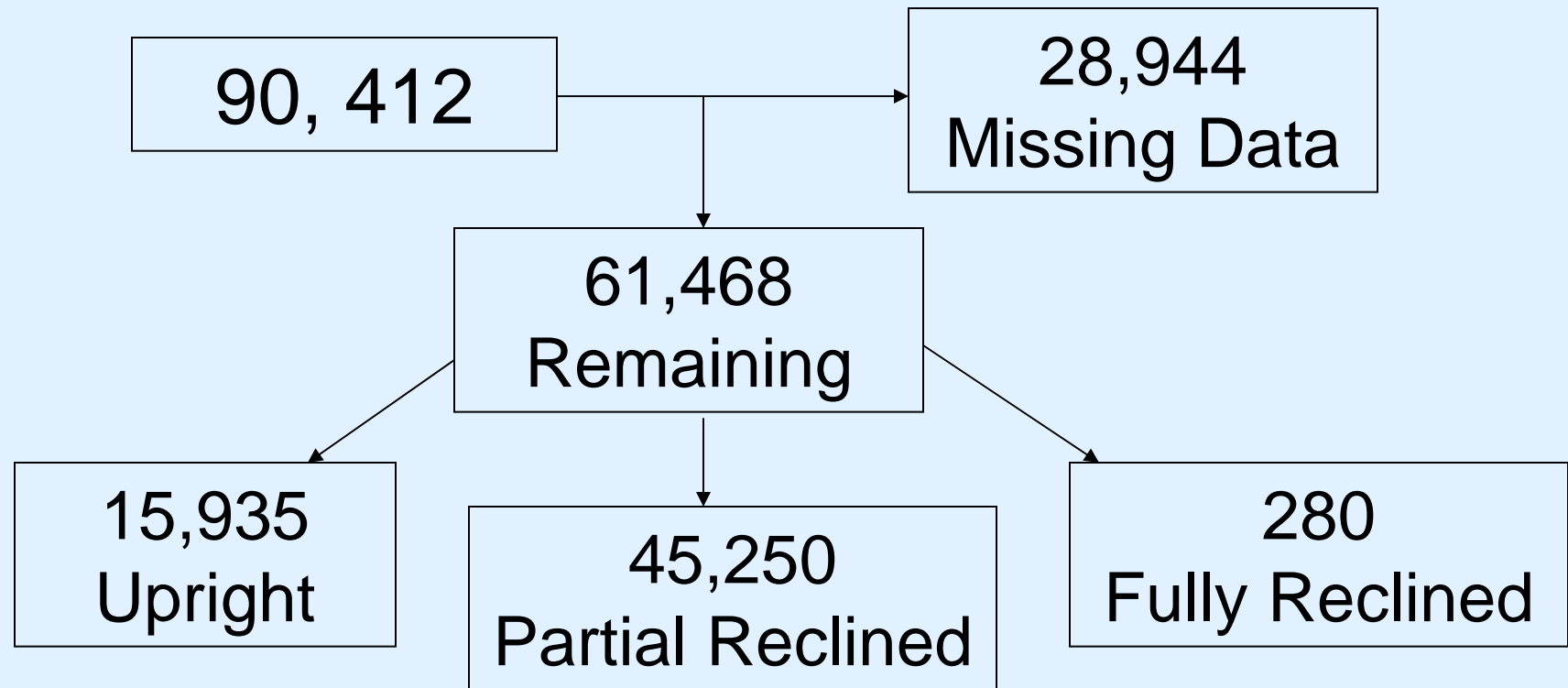
- Patterns of lower extremity injuries
- Associated thoracic trauma in restrained
 - Spine injury from flexion over shoulder belt “clothesline” type
 - Rib fracture patterns
- Positioning of lap belt resulted in upper abdominal injuries

*PHASE II –
NASS/CDS*

Methods:

- Front seat occupants in frontal impact collisions
- Occupant details: Age, gender, height, weight, seatbelt use
- Crash details: Vehicle type, rollovers, ejection, DeltaV, PDOF
- Seat details: seat back and track position
- Outcomes: Mortality, AIS. ISS

Results: NASS/CDS (1995 – 2005)



* No differences in occupant or collision factors

Demographics

	Upright (17.6%)	PR (50%)	FR (0.3%)
Age (yrs)	39.4	35.7	29.6
Male gender (%)	7775 (48.8%)	24705 (54.7%)	197 (70.4%)
Height (cm)	170.1	171.4	174
Weight (kg)	75.9	75.8	79

Vehicle type

Vehicle Type	Upright (17.6%)	PR (50%)	FR (0.3%)
Passenger car	10490 (65.8)	33539 (74.1)	224 (80)
SUV	2350 (14.7)	5661 (12.5)	22 (7.9)
Pickup	1666 (10.4)	3151 (7)	14 (5)

No difference in:

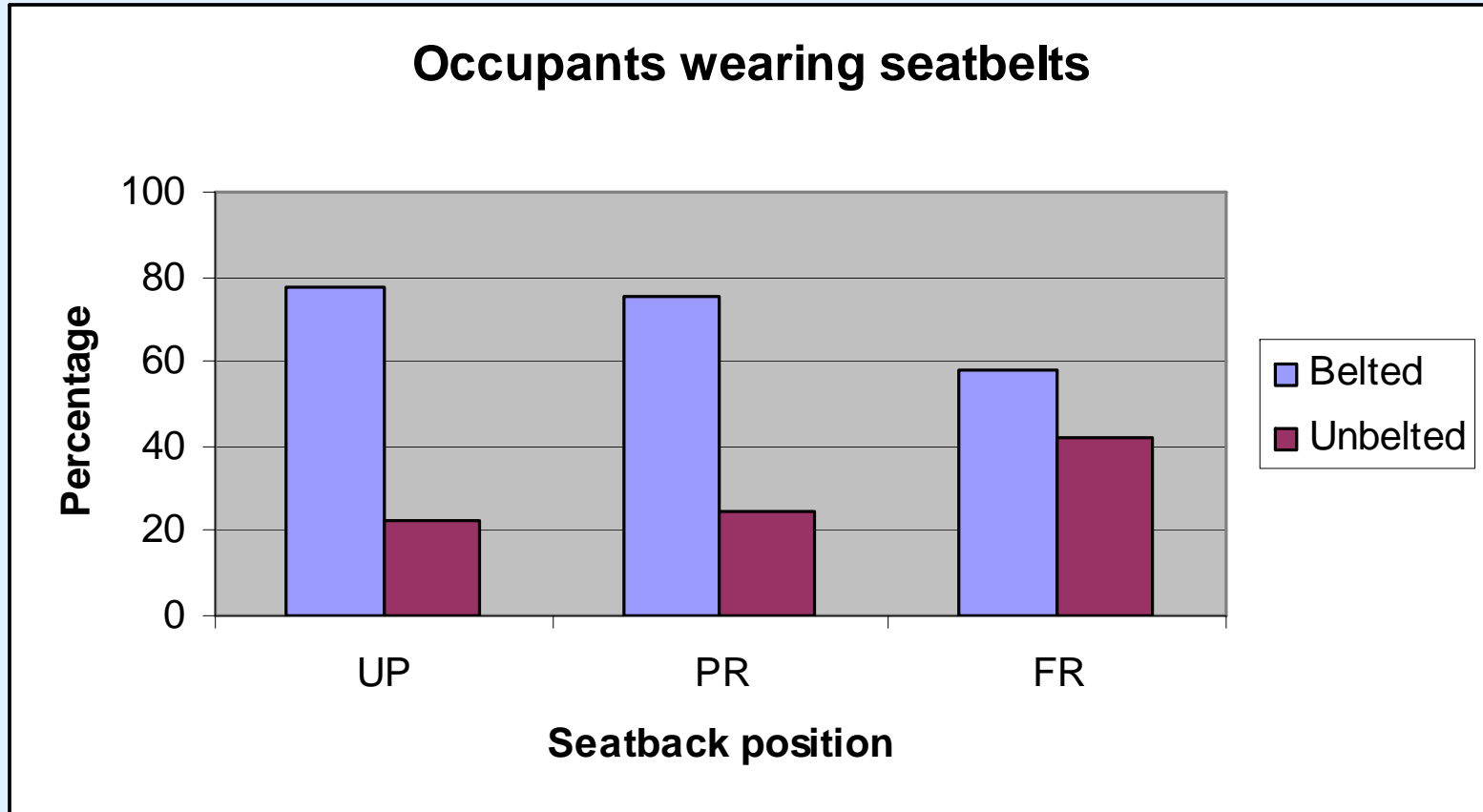
Delta V

PDOF - Direction of Force

Rollovers

Ejections

Seatbelt use



Outcome: ISS

Injury severity
score

Upright
(UP)

Partial Recline
(PR)

Full Recline
(FR)

Mean (SD)

5.7 (14)

5.5 (13.8)

7.2 (16)

1 – 8

8717 (54.7)

23807 (52.6)

120 (42.9)

9 – 25

1832 (11.5)

4799 (10.6)

38 (13.6)

> 25

879 (5.5)

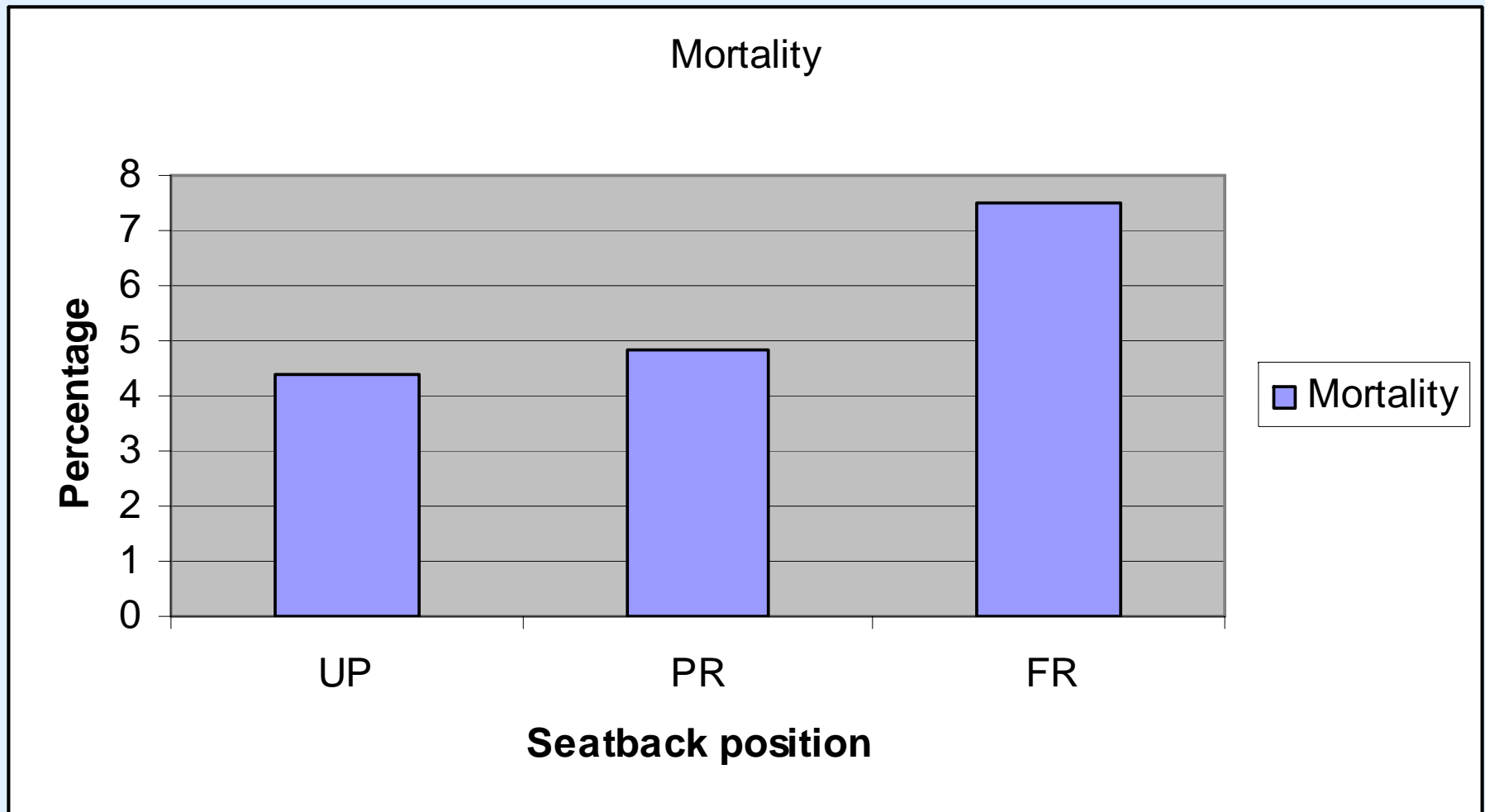
2604 (5.8)

25 (8.9)

Outcome: AIS

AIS	Upright (UP)	Partial Recline (PR)	Full Recline (FR)
Head	0.41	0.42	0.49
Thorax	0.48	0.44	0.53
Abdomen	0.19	0.18	0.22
Spine	0.27	0.26	0.32
Lower extremity	0.55	0.51	0.48

Is there a difference in mortality?



Mortality risk – regression analysis

- Difference in mortality persist when adjusted for age, sex, seatbelt use and type of vehicle

Mortality Risk	Odds Ratio	95% CI
Partial Reclined	1.14	1.02 – 1.22
Fully Reclined	1.77	1.13 – 2.78

Mortality stratified by seatbelt use

Mortality Risk	Belted	Unbelted
Partial Reclined	1.17 (1.03 – 1.34)	1.13 (0.99 – 1.29)
Fully Reclined	1.91 (0.77 – 4.75)	1.71 (0.97 – 3.04)

Overall regression model with interaction term to evaluate seatbelt use and recline – i.e. if seatbelt contributes to mechanism of effect. $P = 0.87, 0.93$ i.e. no significant interaction

Conclusion:

- Fully reclined occupants are predominantly young, male and not wearing a seatbelt
- “Clothesline” type
 - Chest and spinal injuries with the shoulder belt appear to be one mechanism in fully reclined occupants wearing a seatbelt.
- **Fully reclined seats are an independent risk factor for death in motor vehicle collisions**
- Slightly reclined seats have a small increase in mortality