Vertebral Body Fractures of the L-spine in Frontal Crashes

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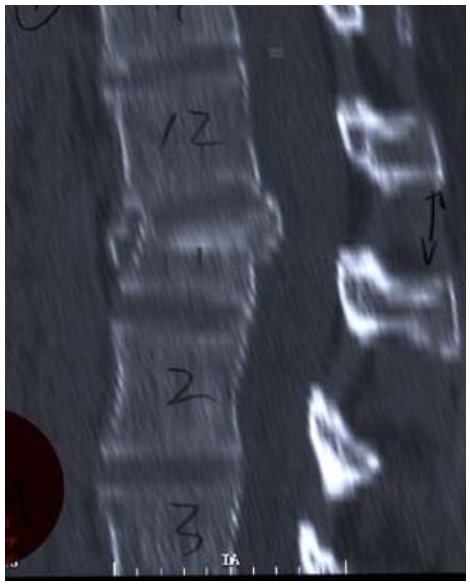
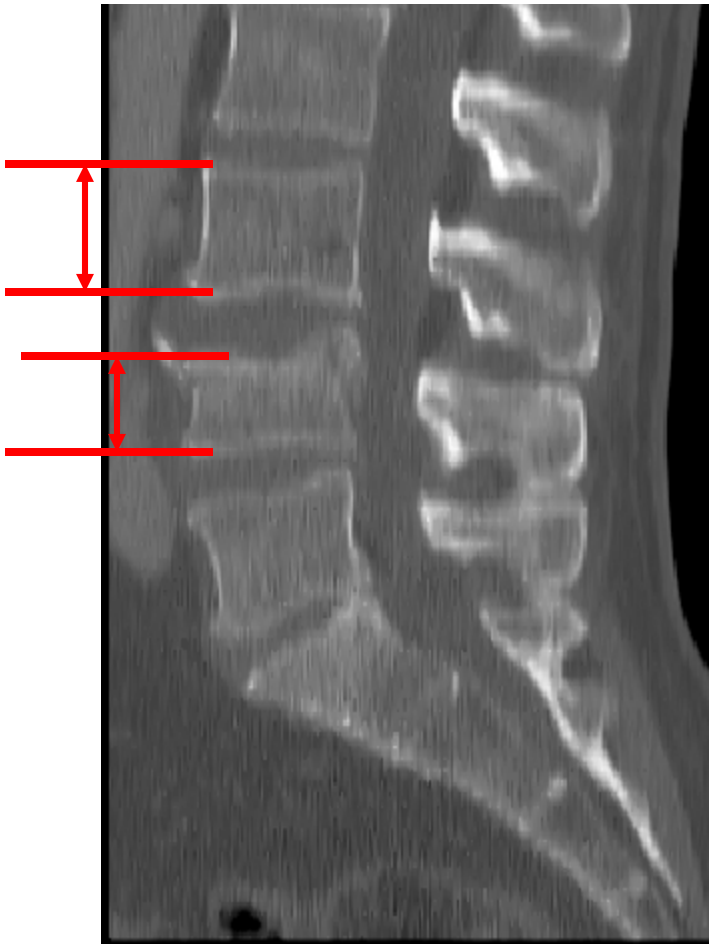


HARBORVIEW
INJURY PREVENTION
& RESEARCH CENTER

L-Spine Major Compression Fractures (LSMC)



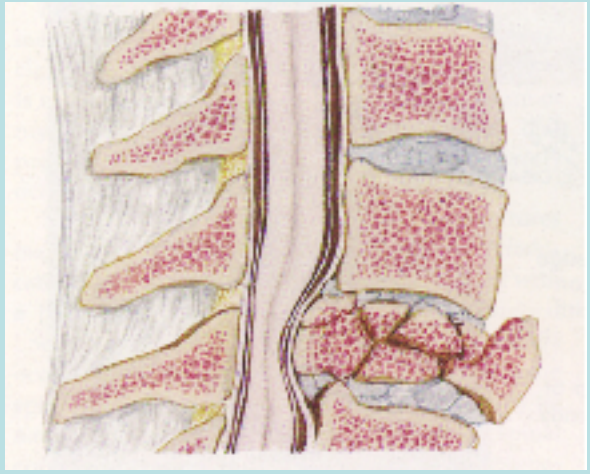
AIS – 650634.3

Vertebral Body fracture with >20% loss of height

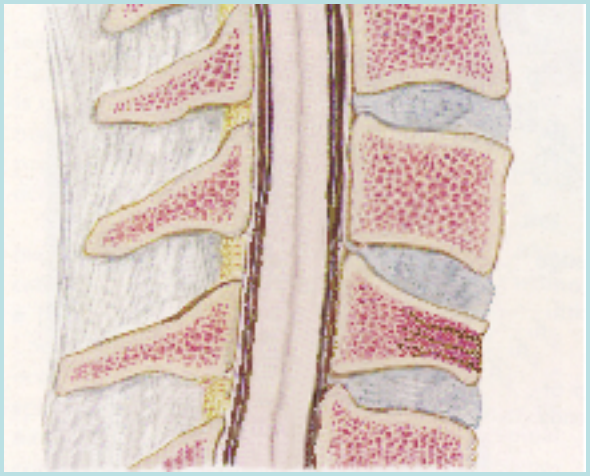
Note: also included 6 of 10 cases coded as a spinal cord injury with fracture of the vertebral body.

Compressive Lumbar Fractures

Burst Fracture



Wedge-Compression Fx



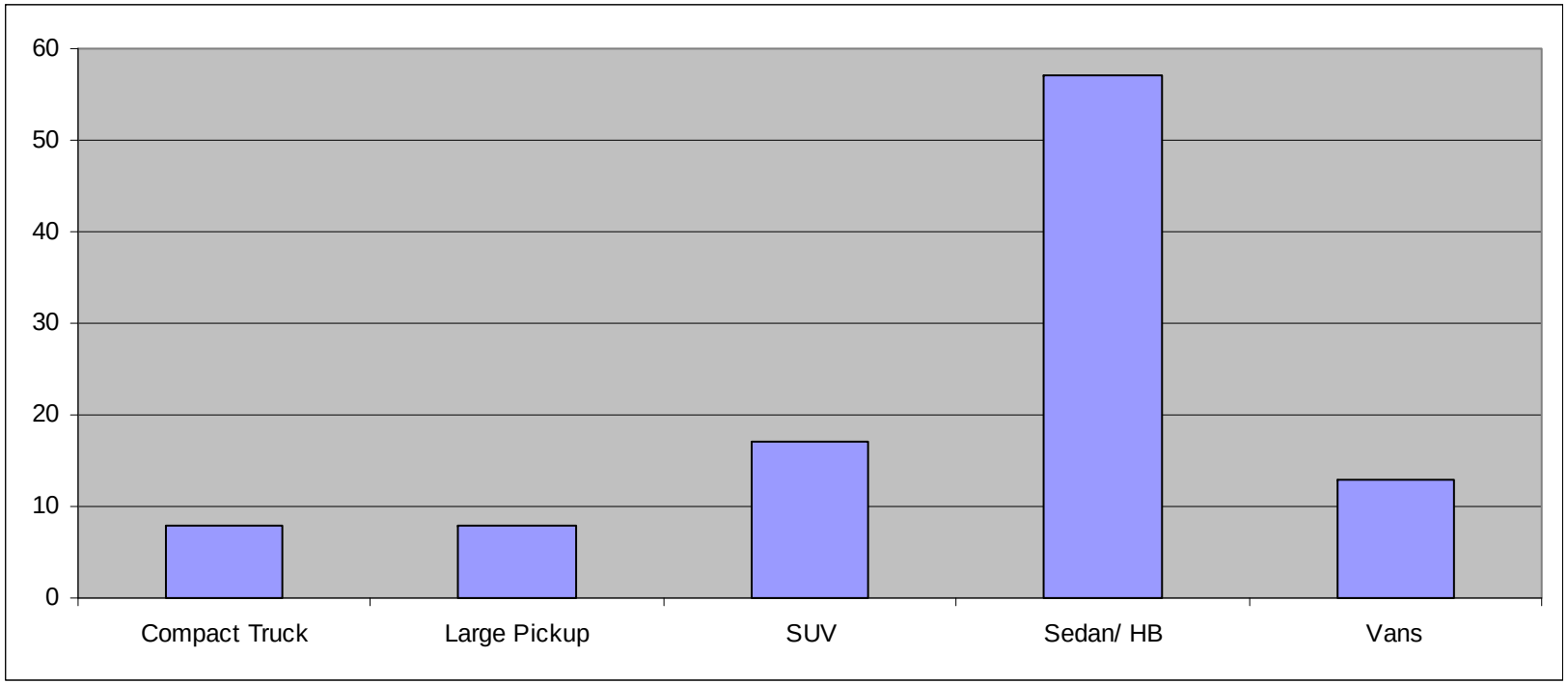
National Automotive Sampling System Data (1993-2008) – LSMC

- 103 cases of LSMC over the period
- Weighted
  - 12,260 total cases, with over 800 annually
- 53% (46) of cases identified as frontal crashes and 26% as non-horizontal impacts

National Automotive Sampling System Data (1993-2008) – LSMC

- Mean Model Year - 1993
- Mean Delta V = 22mph/36kmph
- Mean Age = 35 years
- 50% Female, 50% Male
- Mean Height/Weight = 5’7”, 160lbs.
- 62% drivers, 25% front right position and 13% in second row
- Belts used = 61%, 32% air bag deployed

National Automotive Sampling System Data (1993-2008) – LSMC Vehicle Body Types



N = 103

L-spine Major Compression
CIREN Data

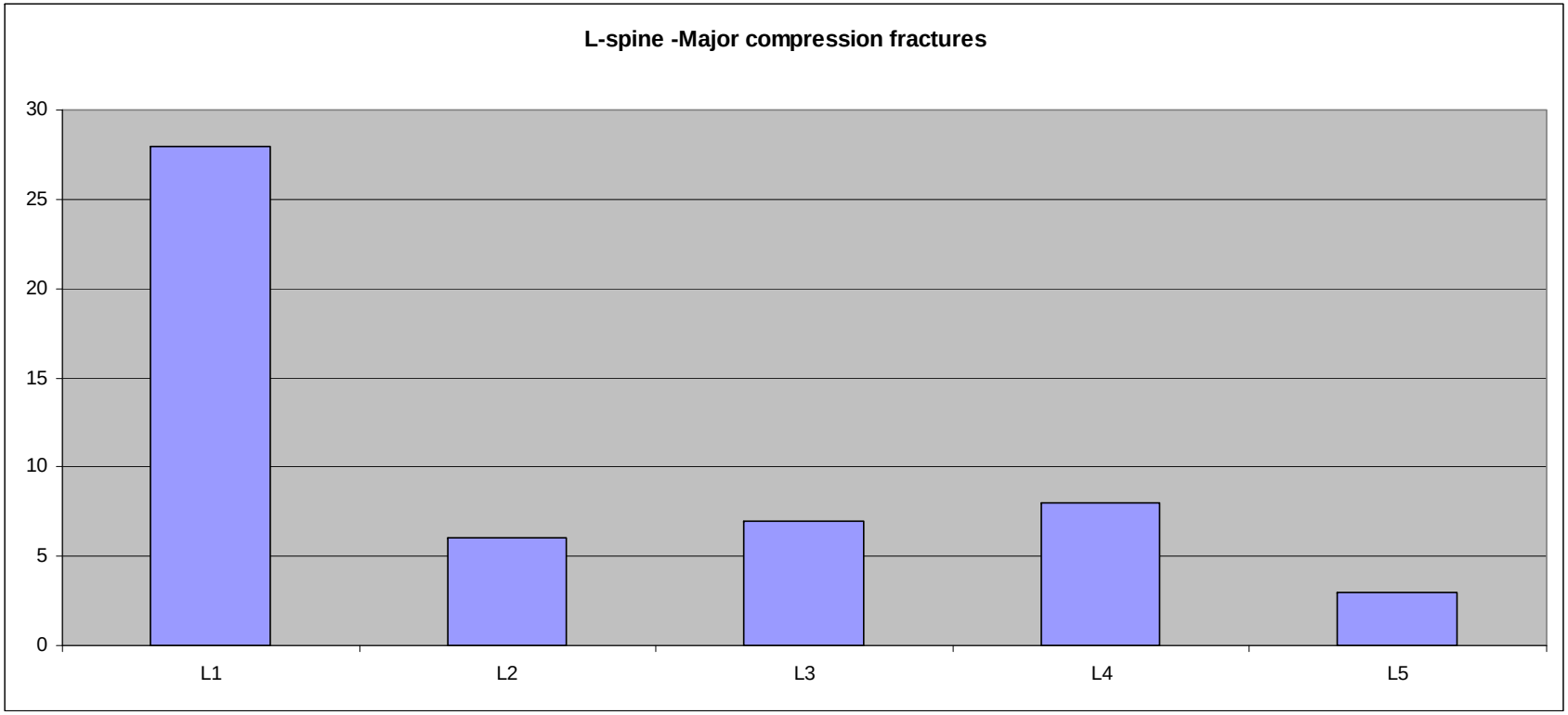
Identified 52 Total cases (1996-2009 CIREN)

Gender - 19 Males, 33 Females

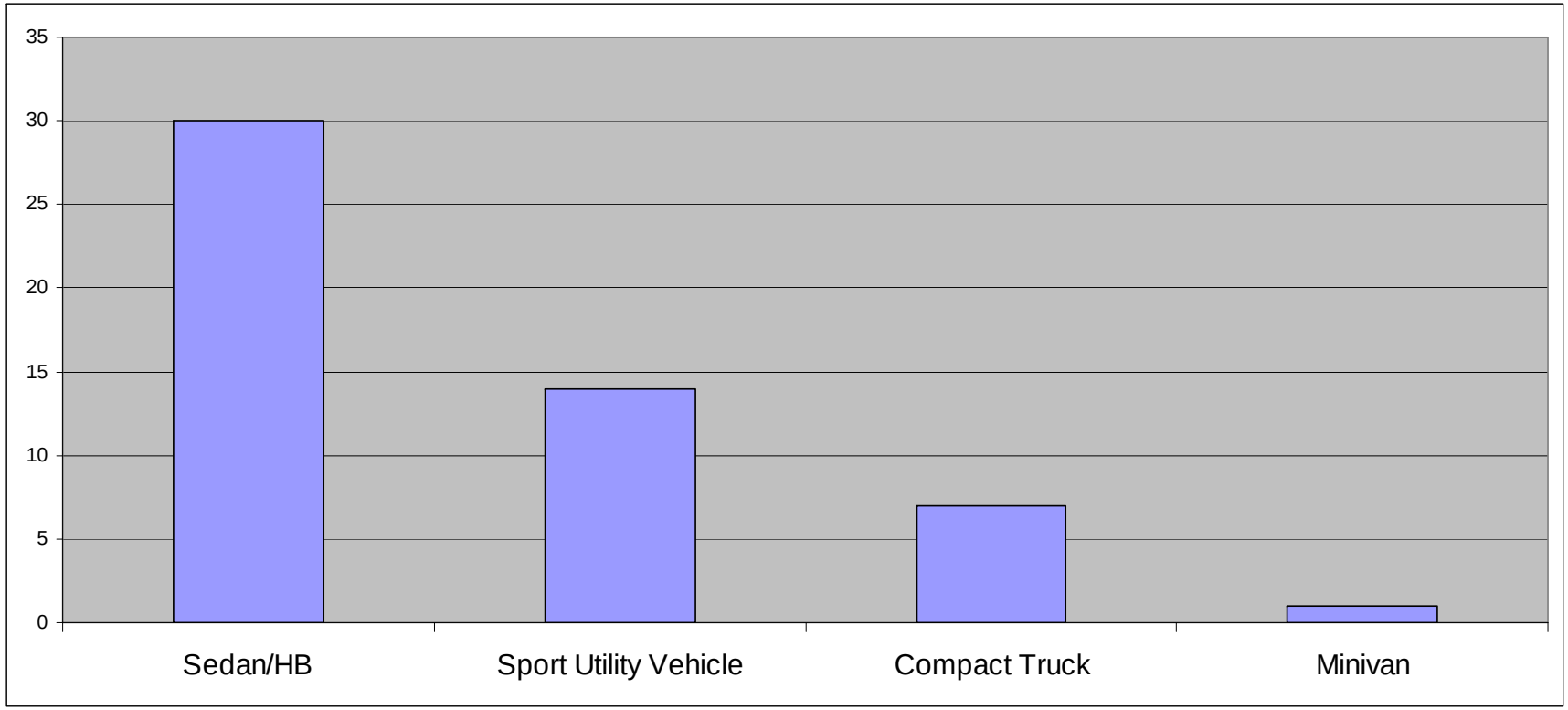
Mean Age - 43 years old

Belts used - 43 yes, 9 none

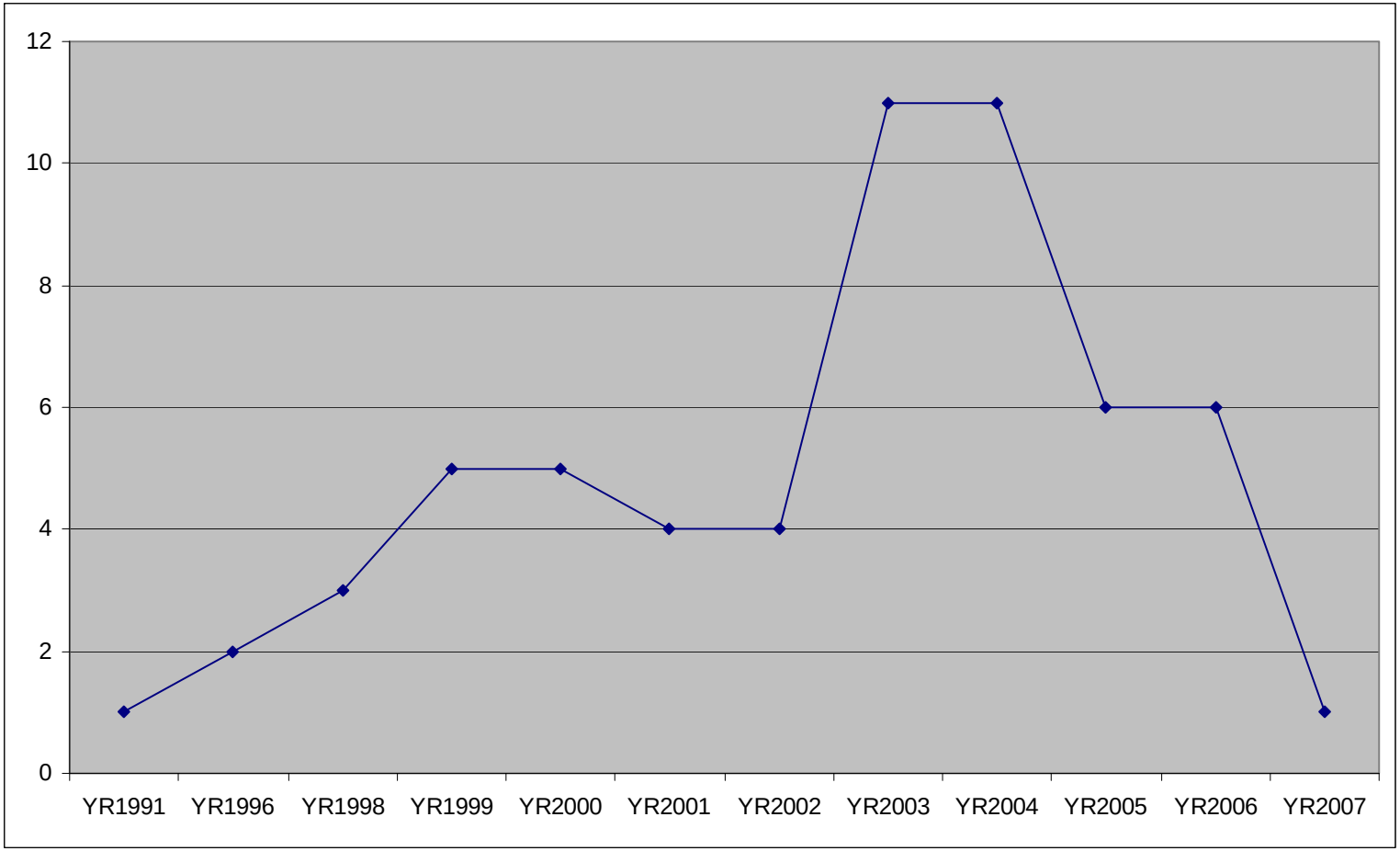
L-spine-Major Compression
CIREN All-Crashes - Fractured locations



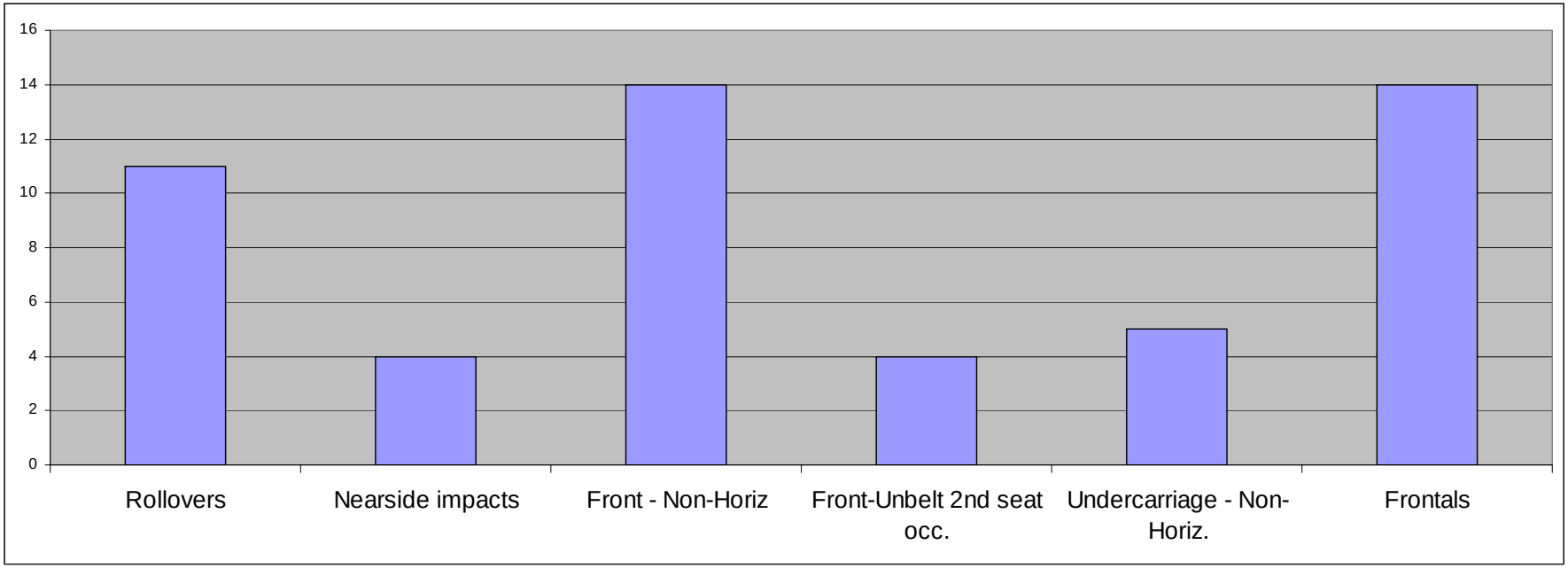
L-spine-Major Compression
CIREN All-Crashes – Body Types



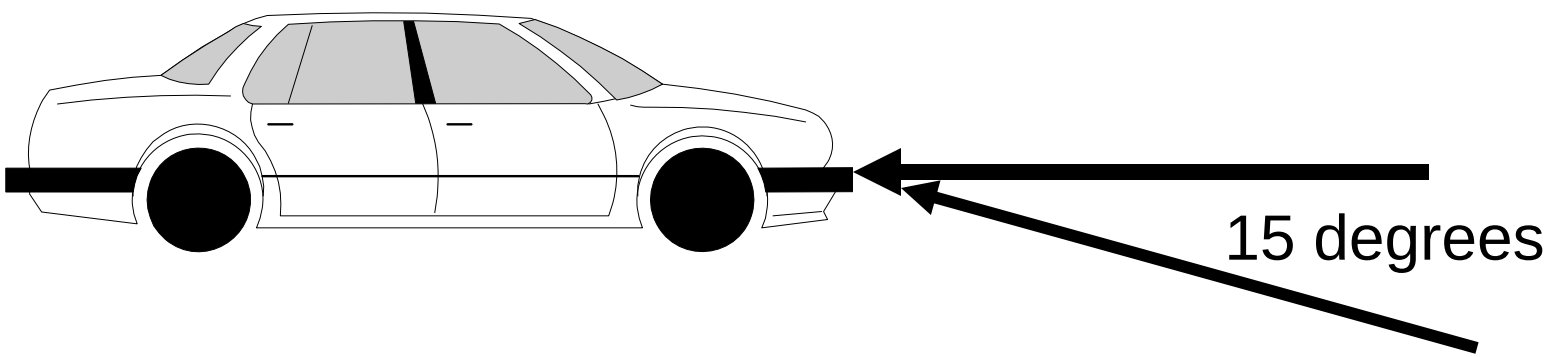
L-spine-Major Compression
CIREN All-Crashes – Model Years



L-spine-Major Compression
CIREN All-Crashes – Crash Types



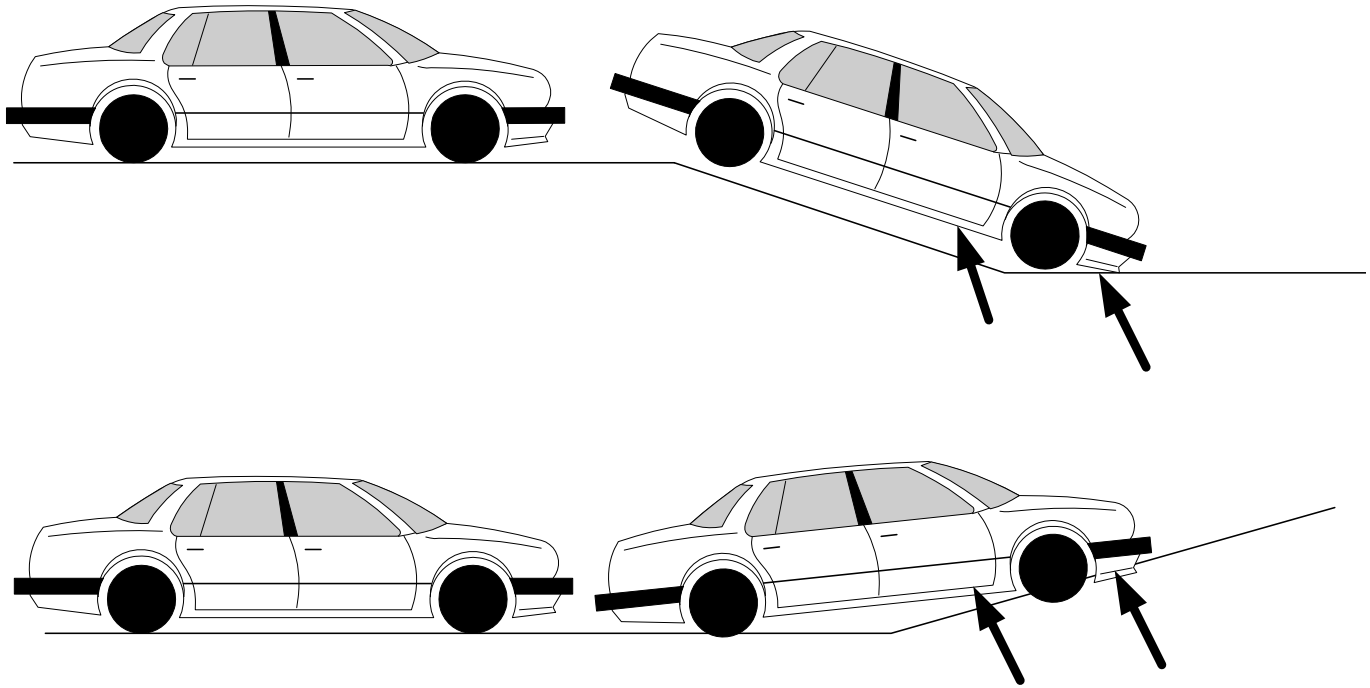
Frontal Non-Horizontals



If the frontal force angle was greater than 15 degrees, then the PDOF is coded as Non-Horizontal to Front plane.

Less than 15 degrees would be classified as Frontal

Frontal – Non-Horizontals
Undercarriage – Non-Horizontals

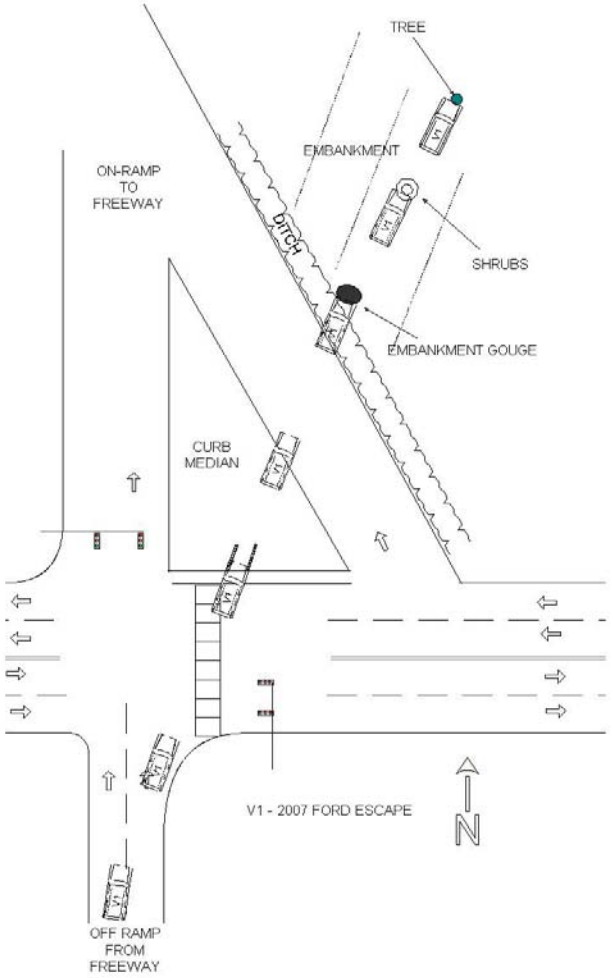


Frontal Non-Horizontal CIREN case example

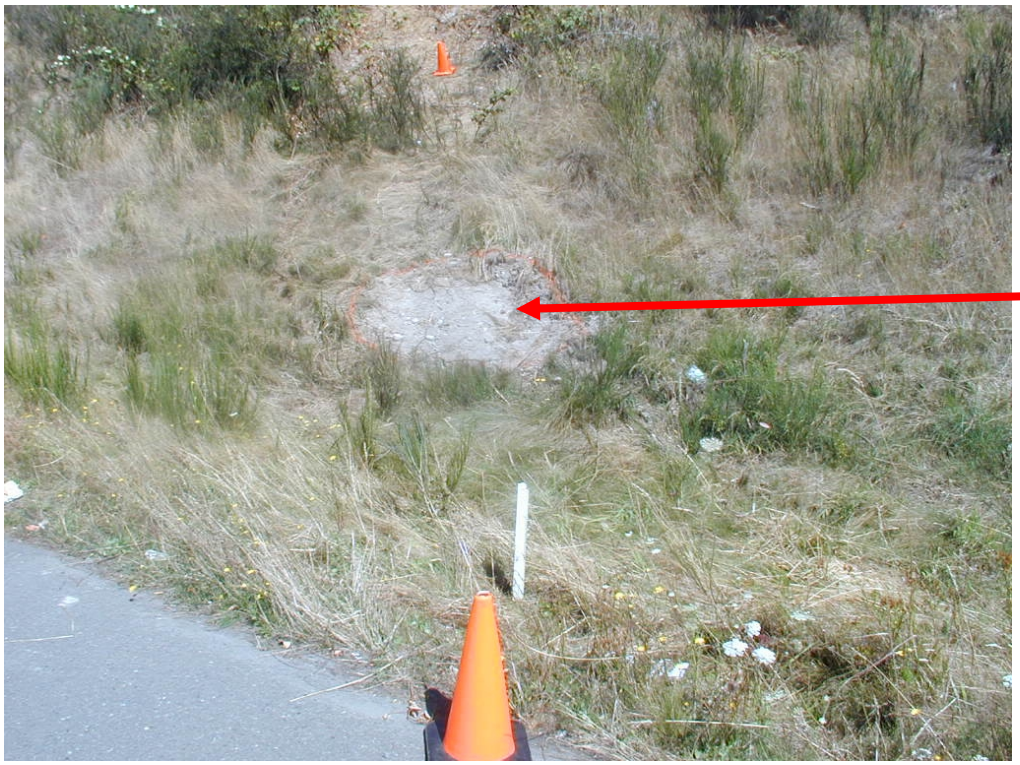
2007 Compact Utility

- 70’s year old female

- Lap/shoulder belt, no airbag deployments



Front Non-Horizontal
CIREN case example



Front Non-Horizontal
CIREN case example

Frontal, undercarriage damage

Front right passenger location

Front Non-Horizontal
CIREN case example

Seat cushion deformity

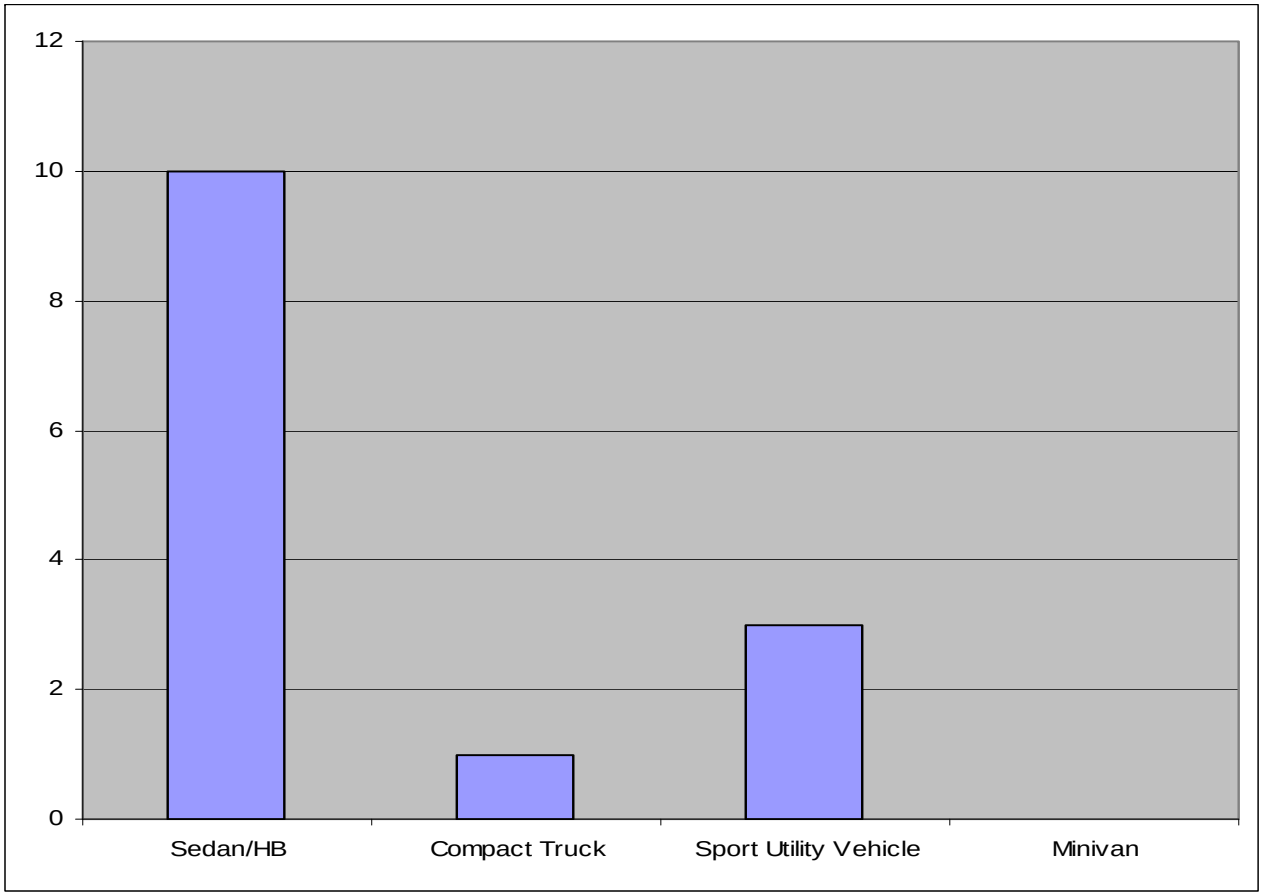
L1 burst fracture occurred

CIREN data
LSMC in Frontals

CIREN Frontals -Demographics

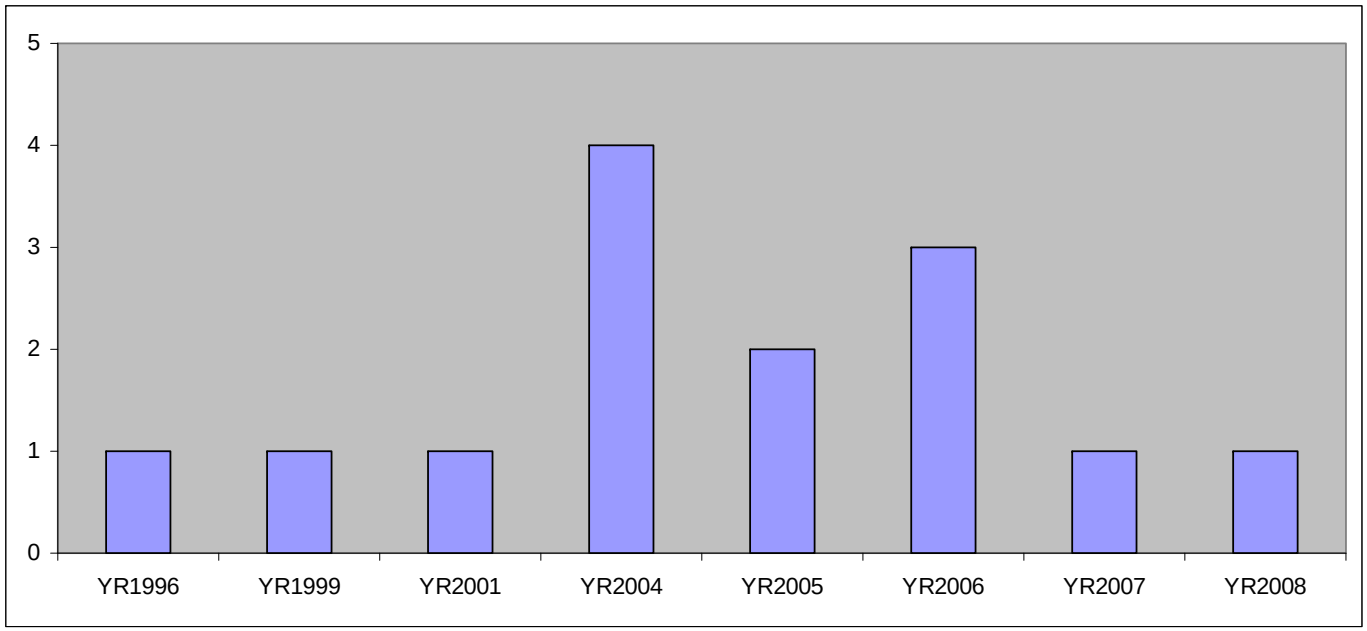
- 14 cases identified as frontal impacts
  - Mean Age = 47 years
  - Gender: 10 of 14 are females
  - Mean height/weight : 5’6”, 153 lbs
  - 12 drivers, 2 front right passengers
  - ALL were lap/shoulder belted
    - 11 of 14 equipped with retractor type pretensioners and all actuated
  - ALL had frontal impact air bag deployment

CIREN data
Frontals only – Body Types

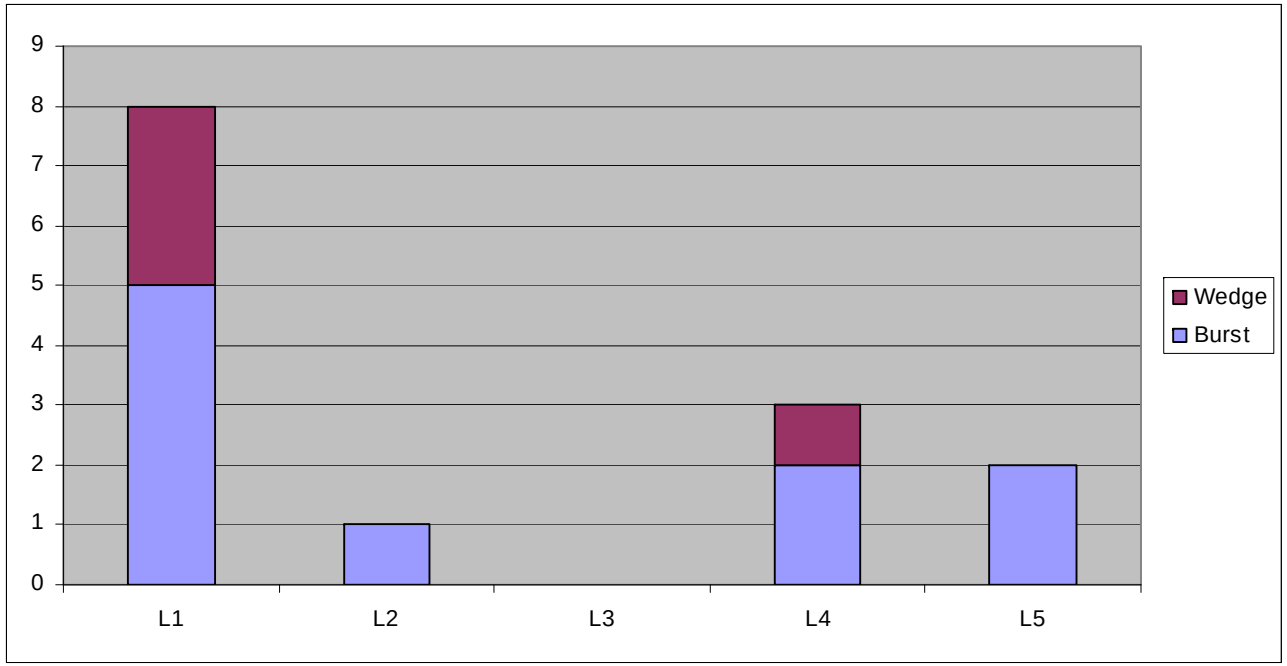


CIREN Data - Frontals only

- Models Years, 11 of 14 are 2004 & later
- Mean Delta V = 26 mph (13/14 coded)
  - Range (10-50mph)



CIREN data - Frontals only
LSMC location, fracture types



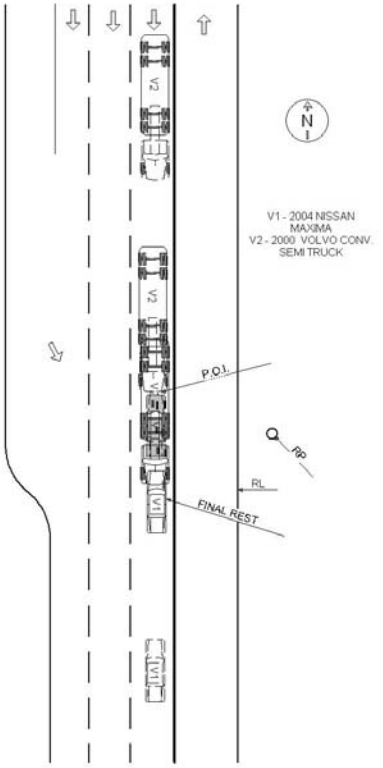
10 – Burst types (compression)

4 – Wedge Compression (flexion, compression/flexion)

Frontal – Wedge Comp. Type

2004 Sedan

Head on with Semi Truck



Frontal – Wedge Comp. Type

Deformation of seat cushion noted

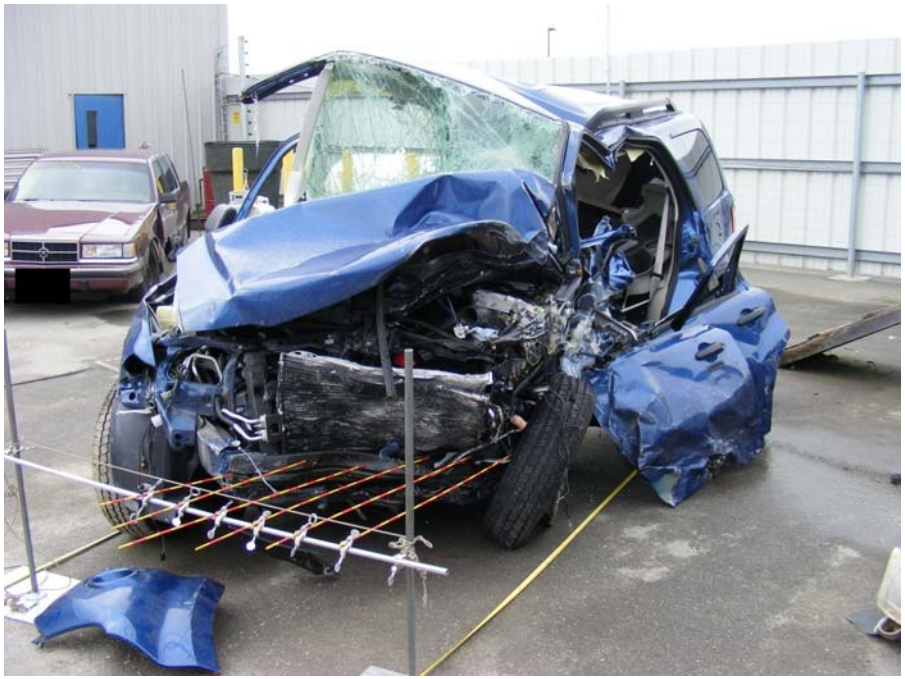
Elderly female

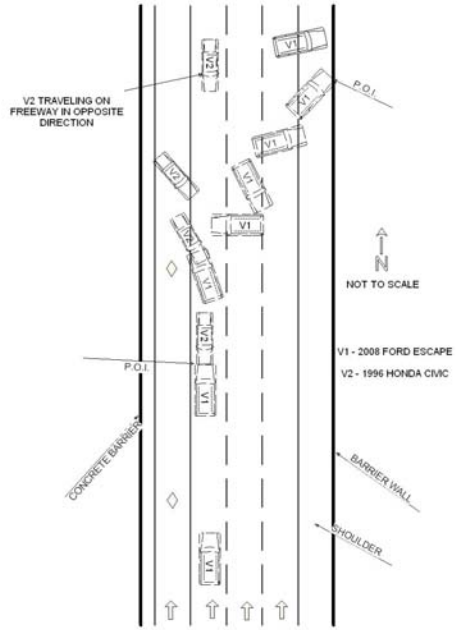
Lap/shoulder belt with retractor pretensioner

L4 body wedge compression fracture

Flexion/Compression

Frontal – LSMC Burst Type





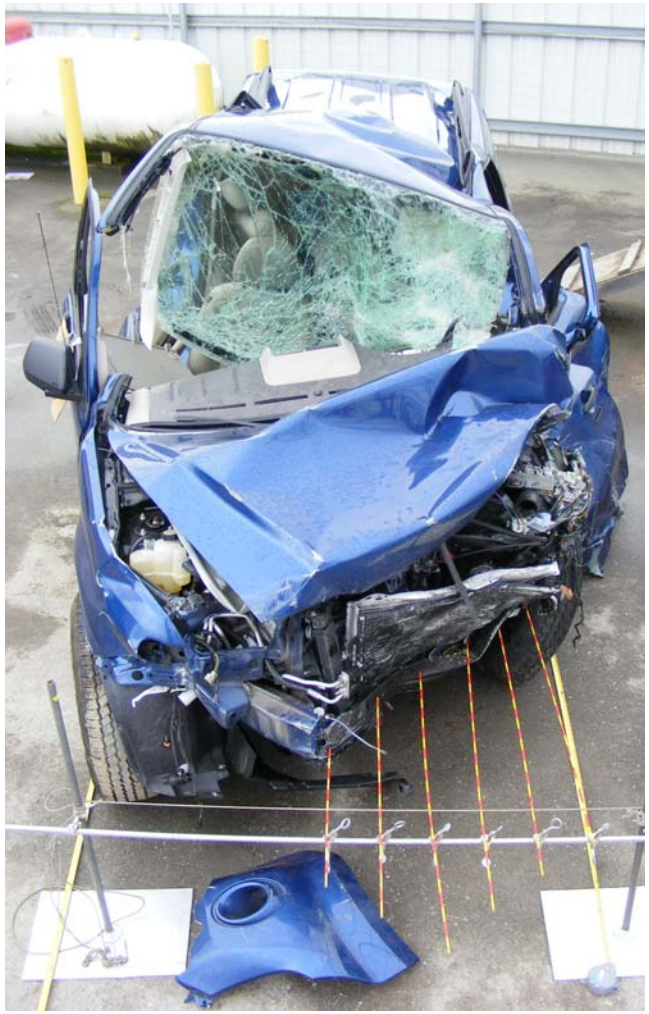
2008 Compact sport utility vehicle

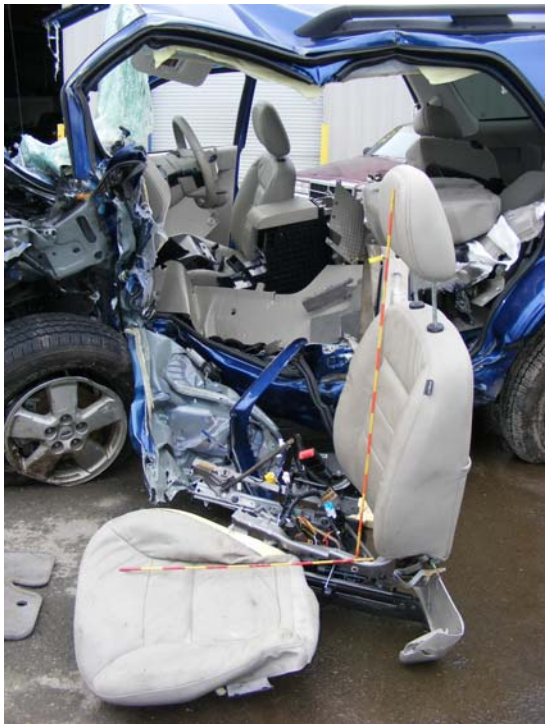
Delta V = 47 mph

20’s year old female

Lap/shoulder belt with pretensioner with front air bag deployment

Frontal – LSMC Burst Type





L5 burst fracture occurred

Frontal – LSMC Burst Type

2006 Two door hatchback

Delta V = 30mph/48kmph

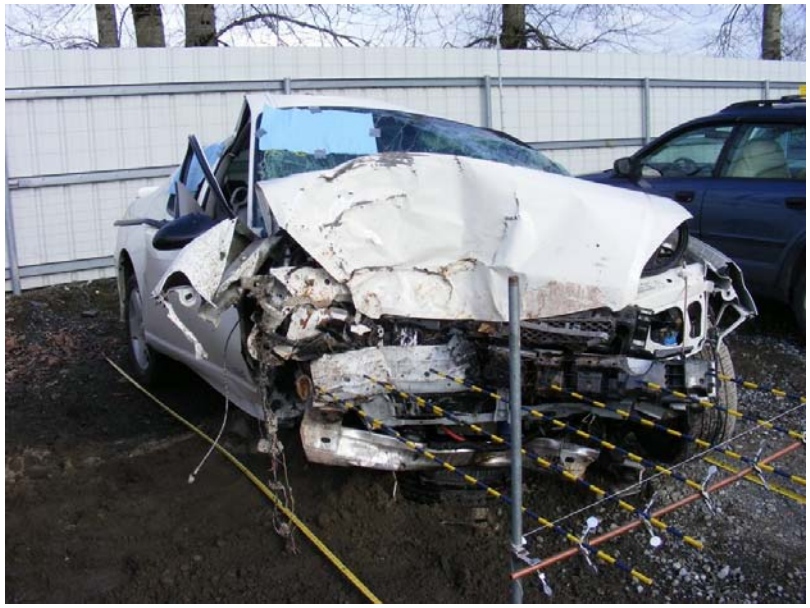
70 year old, male, 5’7”, 141lbs

Lap/shoulder w/ pretensioner

Frontal and Knee bags deployed

L4 burst fracture occurred

Frontal – LCMC Burst Type



Major intrusion with some buckling to floor with some seat cushion deformity.

This case occupant had an L2 LSMC burst type fracture

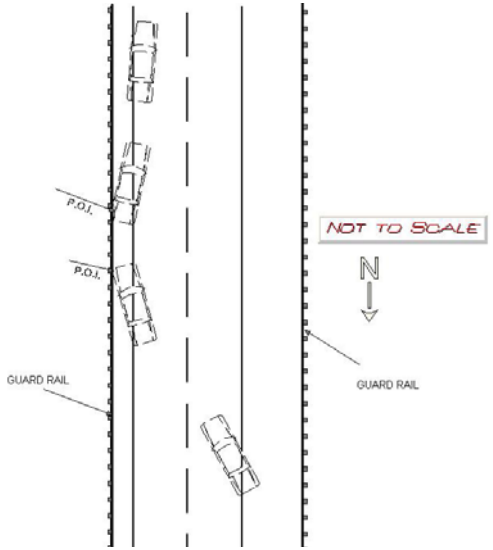
Frontal into Tree

2006 Sedan

Delta V = 50 mph

40’s year old female

Frontal – LSMC Burst Type



Frontal impact to guard rail

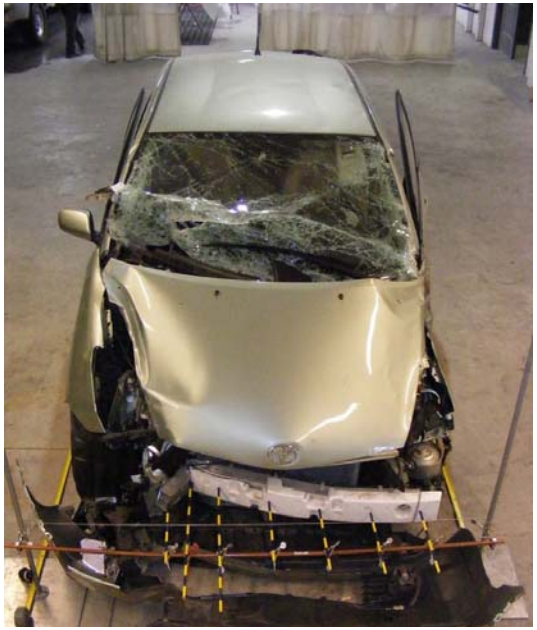
2001 Two door hatchback

Barrier equivalent = 10 mph

Driver – 40 yrs, Female
5’ 7”, 145lbs
Lap/shoulder belt used

L1 Burst fracture occurred

Frontal – Burst Type LSMC



2007 Sedan

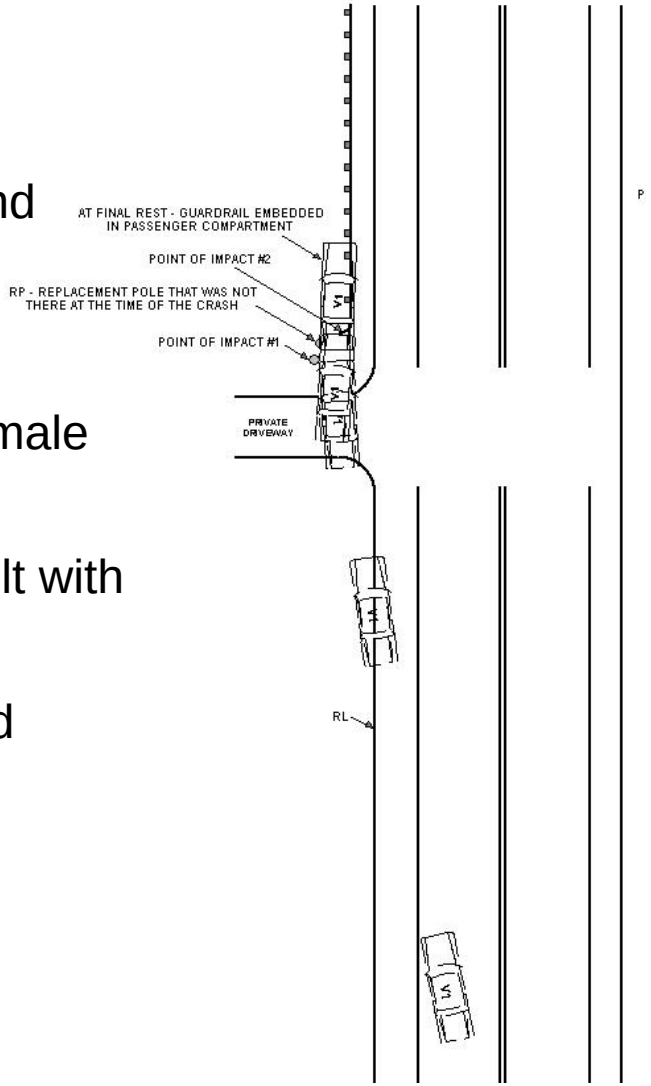
Frontal sideswipe pole and impact to guard rail

Barrier equiv. = 14mph

Driver – 60's year old female 5'4",180lbs.

Lap/shoulder belt with pretensioner

L1 burst fracture occurred

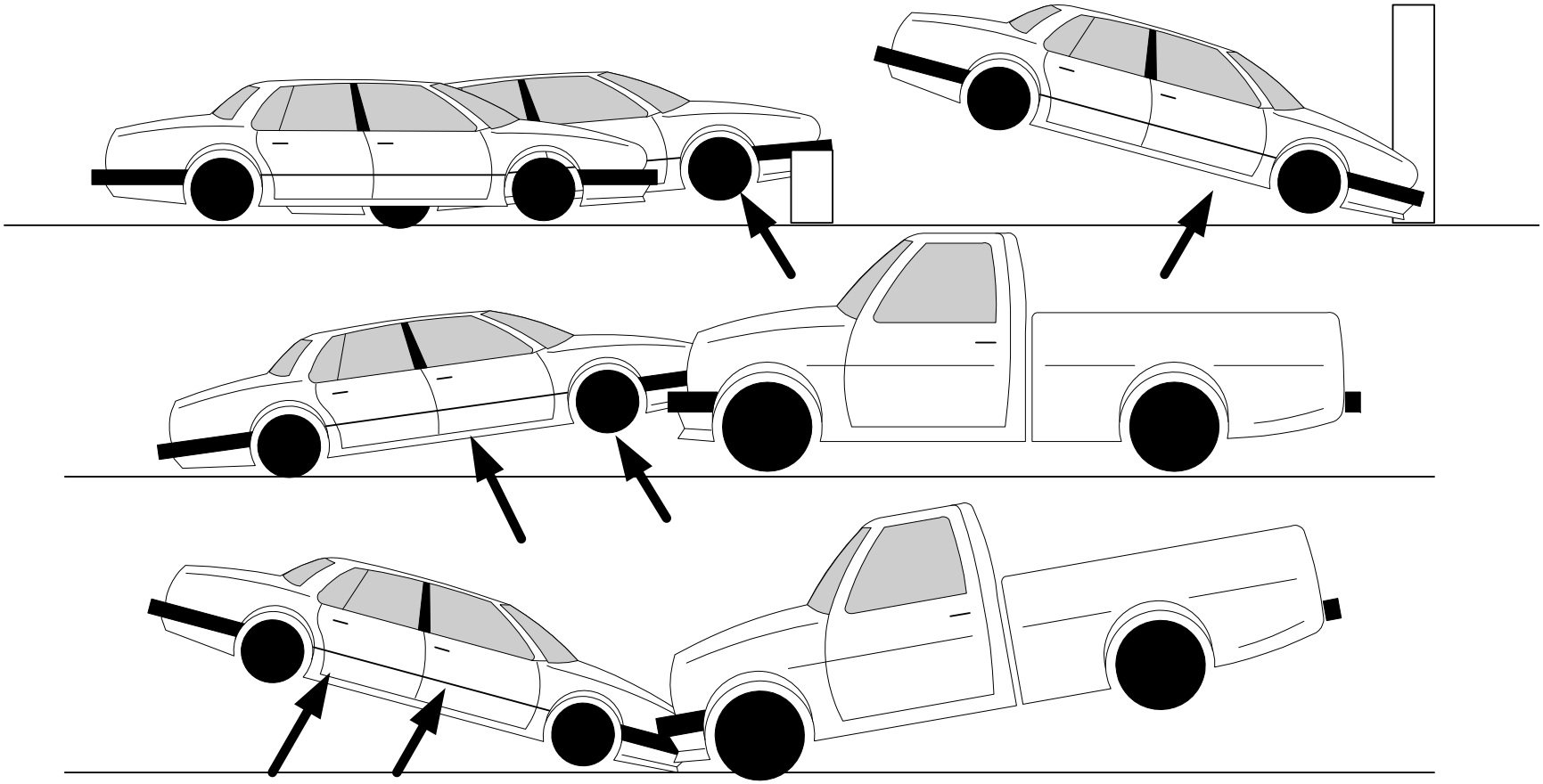


LSMC “Burst Types” involving compression in Frontal Crashes

- Possible Contributing Factors to Examine

I. Some vertical lift of vehicle during impact
II. Seat cushion angle, anti-submarine bar
III. Some involve high Delta V
IV. Belt pretensioners, majority actuated
V. Combination of above

Front or Rear Lift in Frontals



Seat Cushion Angle

Seat Cushion Angle and Deformation

Seat Cushion Angle and Deformation

Exterior Views of Frontal Crash Test

Driver position Pre and Post

Seat cushion deformation during frontal crash tests

Conclusions from All Crashes

- Crashes that involved some non-horizontal force were most common in producing a major LSMC fractures
- More than half occurred at L1 in CIREN
- More than half involved sedans and hatchbacks
- Address new photo guidelines for CIREN teams to document seat cushions

Conclusions on Frontal only group

- The frontal only group had a mean age of 45 years old and majority were females with many who were short stature, and lighter in weight
- Most vehicles were late models (2004 - on)
- Majority were sedans and hatchbacks
- More than half occurred at L1

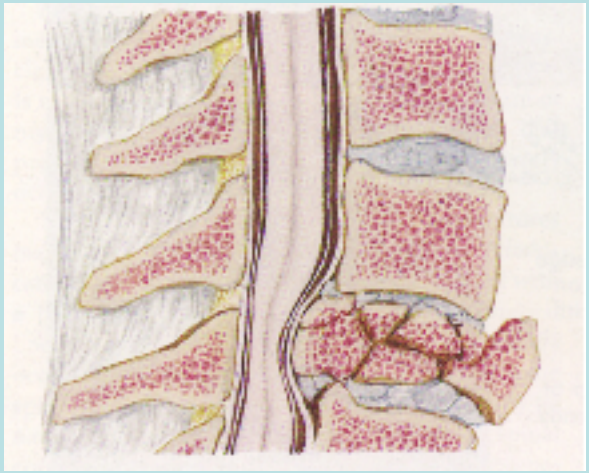
Potential Contributing Factors in Frontal Crashes Producing Major Compression L-spine Fractures

- Belt pretensioners actuated in almost all the cases
- The seat cushion angle and deformity were documented in most cases
- Some lift upward of the front or rear of the vehicle may be occurring during the crash to provide some vertical force
- High Delta V crashes, significant intrusion
- Combination of the above

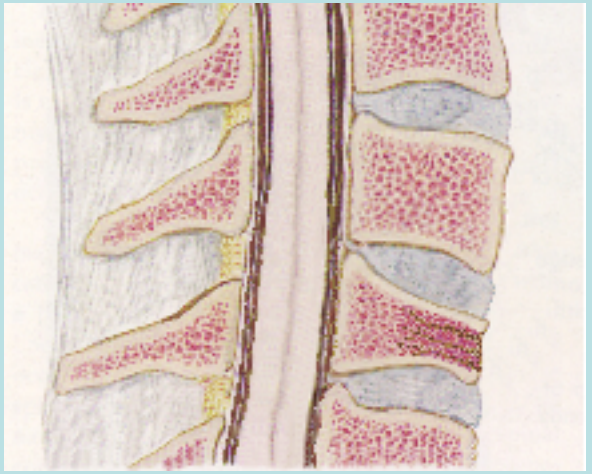
Biomechanical Study

Biomechanical Study

Burst Fracture

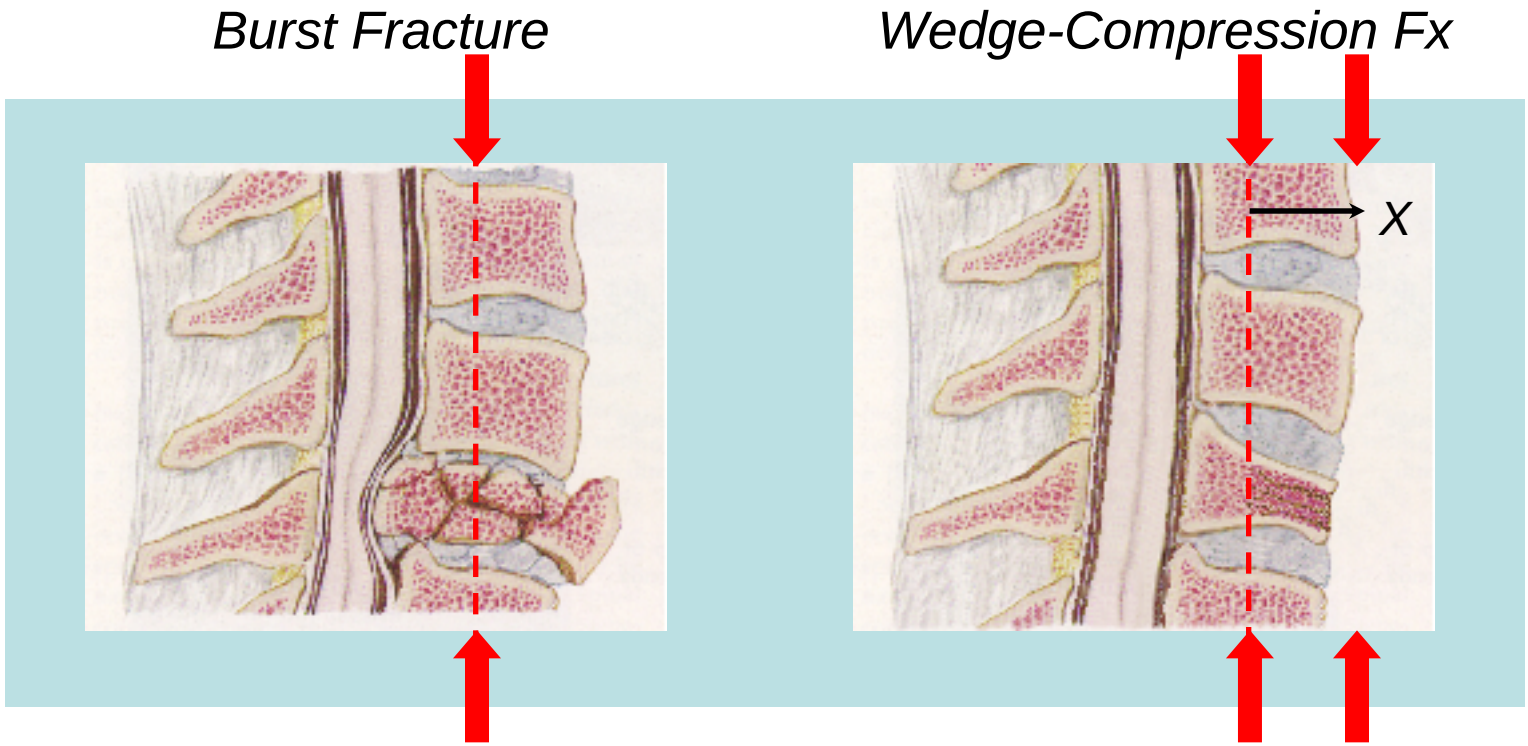


Wedge-Compression Fx



What is the difference in loading associated with these two fracture types?

Biomechanical Study

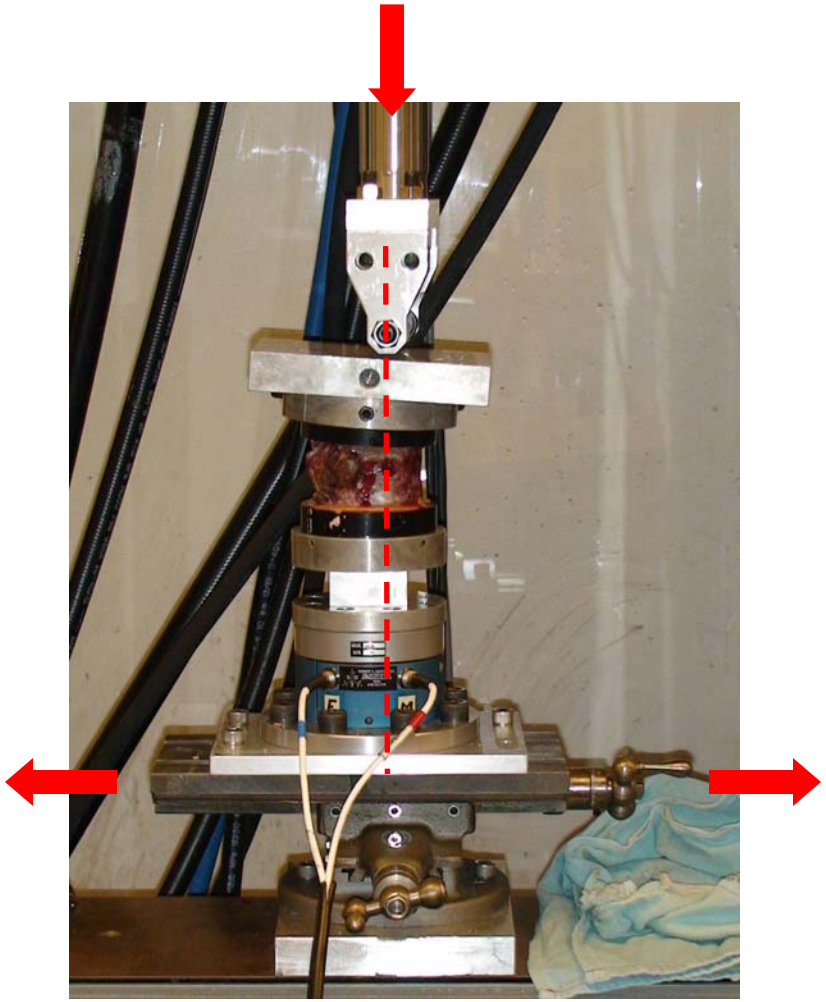


[Q]: Assuming similar loading rates and compression forces (magnitude), will the location of the force vector determine the fracture type?

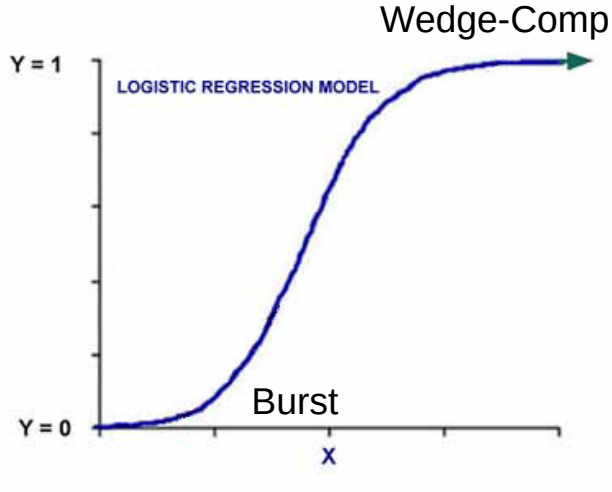
Biomechanical Study

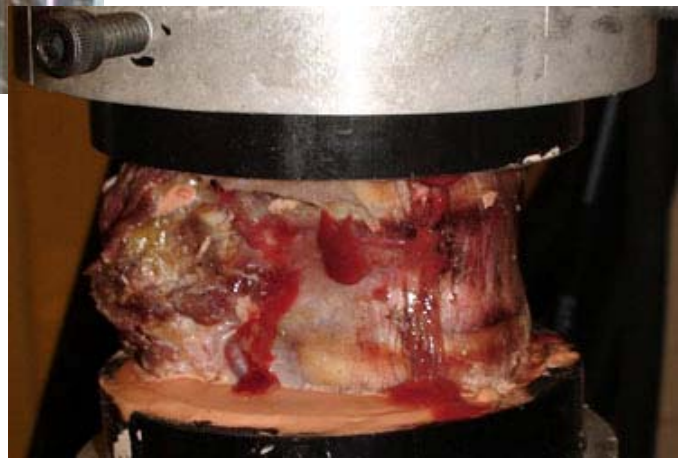
Methods

- *Human lumbar segments: T12-L1-L2 and L3-L4-L5*
- *High-rate MTS: 0.5-1.0 m/s*
- *X-Y Stage*
- *6-Axis load cell*
- *"Tipping Point"*
- *Normalize X (% V.B. width)*



Biomechanical Study





- *Failure load (forces/moments)*
- *Injury type: Burst / Wedge-Compression*

Thank You