Vertebral Body Fractures of the L-spine in Frontal Crashes

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L-Spine Major Compression Fractures (LSMC)

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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*

- **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

- 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
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

Sedan/HB
Sport Utility Vehicle
Compact Truck
Minivan
L-spine-Major Compression
CIREN All-Crashes – Crash Types

- Rollovers
- Nearside impacts
- Front - Non-Horiz.
- Front-Unbelt 2nd seat occ.
- Undercarriage - Non-Horiz.
- Frontals
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

Sedan/HB
Compact Truck
Sport Utility Vehicle
Minivan
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

Elderly female
Lap/shoulder belt with retractor pretensioner
L4 body wedge compression fracture
Flexion/Compression

Deformation of seat cushion noted
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

Frontal into Tree
2006 Sedan
Delta V = 50 mph
40’s year old female

Major intrusion with some buckling to floor with some seat cushion deformity.
This case occupant had an L2 LSMC burst type fracture
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

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