Non-Ankle Lower Extremity Fractures [NALEF] in Frontal Crashes: Bio-Mechanical Interactions of Driver Height, Vehicle Type, Seatbelt Use and Crash Delta-V

Refaat Hanna MD MA, Samir M. Fakhry MD, Rodney W. Rudd PhD, Anne Rizzo MD, Christine Burke, James D. Bean, Greg Stadter, Christopher Sherwood MS
Inova Regional Trauma Center
Inova Fairfax Hospital
Falls Church, Virginia, USA

ACS LEVEL ONE Trauma Center
PURPOSE
To determine the role of occupant and vehicle characteristics on Non-Ankle Lower Extremity Fractures (NALEF). We excluded ankle fractures from the analysis. Ankle fractures have been addressed heavily in many studies and the mechanism of injury has been well established.

The independent variables tested are:

1) Driver height
2) Vehicle type
3) Seatbelt use
4) Crash Delta-V (Change in velocity)
METHODS

Retrospective analysis of:

1. Crash Injury Research and Engineering Network (236 cases)

2. National Automotive Sampling System (823 cases)
METHODS

Inclusion Criteria:
- Drivers aged ≥ 16 years
- Frontal vehicle crash (PDOF 11 to 1 O’clock)
- Injuries with Abbreviated Injury Scale (AIS)* of ≥ 2
- Vehicle model year 1996 to 2004
- Vehicle type: Passenger Cars
  Sports Utility Vehicles (SUV)/Light Trucks

Exclusion Criteria
Rollovers, fires, ejection, more than one impact and injuries with unknown AIS
In this study, Driver Heights were grouped according to the 5th, 50th and 95th Hybrid III dummies

<table>
<thead>
<tr>
<th>Dummy Height</th>
<th>cm</th>
<th>inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid III 5th percentile female</td>
<td>152</td>
<td>59.8</td>
</tr>
<tr>
<td>Hybrid III 50th percentile male dummy</td>
<td>168</td>
<td>66.1</td>
</tr>
<tr>
<td>Hybrid III 95th percentile</td>
<td>188</td>
<td>74</td>
</tr>
</tbody>
</table>

**Height Distribution for Cases Included in the Study**

![Height Distribution Chart]

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There was no significant difference in the magnitude of intrusion of left instrument panel (IP) & left toe pan between passenger cars & SUV/Light Trucks.

### Intrusion

<table>
<thead>
<tr>
<th>Intruded Part</th>
<th>Odds Ratio</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left IP* / KB^</td>
<td>1.15</td>
<td>0.32</td>
</tr>
<tr>
<td>Left Toe Pan</td>
<td>1.01</td>
<td>0.99</td>
</tr>
</tbody>
</table>

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Body Mass Index (BMI)

• We examined the relationship between BMI and different NALEF injuries.

• The results did not show any significant relationships between NALEF and BMI.
Comparing to NASS

Hip/Pelvis Fractures in Passenger Cars
CIREN VS. NASS

Femur Fractures in Passenger Cars
CIREN VS. NASS

Tibia-Fibula Fractures in Passenger Cars
CIREN VS. NASS
Rationale for Combining NASS & CIREN Data

It is a prerequisite of a well-designed study to have a clear statement for data quantity, quality and reliability to increase the power of the study results. Power is the likelihood that a study will detect a true difference of a given magnitude between groups if it actually exists (i.e., a true positive).

Power is a function of study sample size. The concept of power is extremely important because the lack of it (i.e., the study size is too small) can lead to statistical insignificance in the presence of actual difference (false negative).
Hip/Pelvis
In passenger vehicles, there is a significant positive relationship between driver height and risk of hip/pelvis injuries.
Hip/Pelvis Fractures in SUV/Light Trucks by Driver Height

In SUV/Light Trucks, there is not a specific pattern of relationship between driver height and risk of hip/pelvis injuries.

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In passenger cars, after adding seatbelt use and crash Delta-V as possible confounders, the positive relationship between driver height and risk of hip/pelvis injury did not change.
Hip/Pelvis Fractures in Passenger Cars by Seatbelt Use

**OR = 2.2**
**P = 0.015**

OR = 1.33
**P = 0.39**

Seatbelt use provided significant protection to the medium height group.

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Hip/Pelvis Fractures in Passenger Cars by Delta-V

Medium height drivers had a lower risk of hip/pelvis injuries at lower and higher Delta-V.

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Femur
In passenger cars, there is a significant positive relationship between driver height and risk of femur fractures.

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In SUV/Light Trucks, there is no specific pattern of relationship between driver height and risk of femur fractures.
In passenger cars, after adding seatbelt use and crash Delta-V as possible confounders, the positive relationship between driver height and risk of femur fracture did not change.
Femur Fractures in Passenger Cars by Seatbelt Use

Seatbelt use provided significant protection to the medium height group

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Delta-V increases the risk of femur fractures among the three height groups.
Knee/Patella
Knee/Patella Fractures in Passenger Cars by Driver Height

In passenger cars, there is not a specific pattern of relationship between driver height and risk of knee/patella injuries.
In SUV/Light Trucks, shorter drivers had a significantly lower risk. Overall, there was no statistically significant pattern of relationship between driver height and risk of knee/patella injury.
Tibia / Fibula
In passenger cars, there is a negative relationship between driver height and risk of tibia/fibula fractures.

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In SUV/Light Trucks, taller drivers had a significantly lower risk. Overall, there was no statistically significant pattern of relationship between driver height and risk of tibia/fibula fractures.
In passenger cars, after adding seatbelt as possible confounder, the negative relationship between driver height and risk of tibia/fibula fracture, did not change.

In passenger cars, after adding seatbelt as possible confounder, taller drivers remained at a lower risk of tibia/fibula fracture compared to the other two groups.
Tibia/Fibula Fractures in Passenger Cars by Seatbelt Use

- OR = 1.87
  \( P = 0.06 \)
- OR = 0.63
  \( P = 0.11 \)
- OR = 1.79
  \( P = 0.103 \)

Seatbelt use provided significant protection to short drivers.

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Tibia/Fibula Fractures in Passenger Cars by Delta-V

Delta-V increases the risk of tibia/fibula fractures among the three height groups.
POSSIBLE REASONS FOR:

- Increased Risk of Below Knee Injuries for Shorter Drivers
- Increased Risk of Above Knee Injuries for Taller Drivers

5th Female 95th Male

Based on Crash Research Conducted by the University of Virginia (UVA)

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CONCLUSIONS

• Driver height plays a significant role in the incidence of specific NALEF injury type:
  - Taller Drivers sustain more above knee NALEF injuries
  - Shorter Drivers sustain more below knee NALEF injuries
    “A trade-off pattern”

• Crash Delta-V increases the risk of NALEF injury - the pattern of injury remains significantly influenced by driver height
CONCLUSIONS

• Seatbelt protection is significant for above knee NALEF injuries - the pattern of injury remains significantly influenced by driver height.

• Seatbelt protection varies according to driver height and NALEF part:
  ➢ Drivers of medium height are offered more above knee protection by seat belt use compared to the other two groups
  ➢ Shorter drivers offered more below knee protection by seat belt use compared to the other two groups
CONCLUSIONS

- CIREN and NASS data showed a consistent relationship between driver height and risk of NALEF injury
- Compared to NASS, CIREN offers unique information:
  - more detailed medical information (e.g. acetabulum fracture) which can be obtained using ICD-9 codes
  - mechanism of injury obtained from case summaries
  - in the near future, mechanism of injury will be available in CIREN via the Bio-tab
  - outcome of injury measured via SF-36 at 6 and 12 months in CIREN vs. NASS where outcome obtained through working days lost in first 60 days post-discharge
Questions?