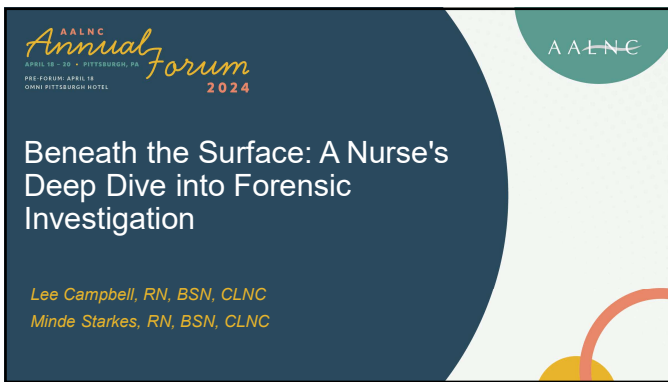
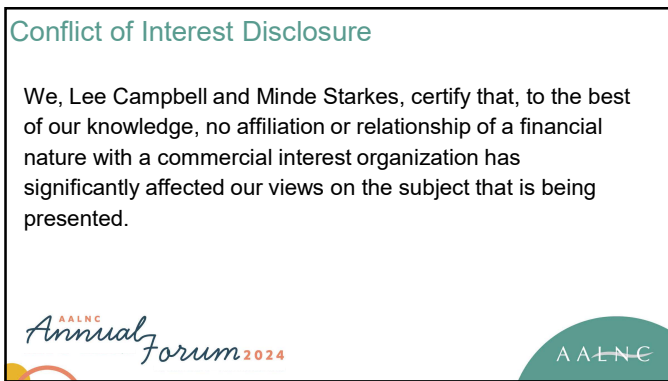




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3

Learner Outcomes/Objectives

- Educate LNCs regarding engineering and scientific investigation and analysis firms and their capabilities
- Define "Forensic Engineering," specifically biomechanical injury and human factor analysis
- Review case examples involving forensic engineering highlighting how forensic nurses identify critical information that assists the engineer in case analysis



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ESi Background

- Engineering and scientific investigation and analysis firm
- Investigate failures, accidents, incidents, and disasters
- Founded in 1987, 20 offices in 14 states, over 200 engineers, scientists, and medical professionals
- Work on projects with numerous companies, organizations, and governments in all 50 states and internationally
- Large warehouses with test facilities, labs, and equipment (research)



5

ESi's Areas of Expertise

- Biomechanical & safety
- Accident reconstruction
- Injury analysis/investigation
- Human factor analysis
- Regulatory compliance and premises safety
- Risk assessment
- Electrical & Electronics
- Fire & Explosion
- Industry Support Services
- Materials Science
- Mechanical systems
- Oil, Gas & Industrial
- Products
- Regulatory compliance
- Safety evaluations
- Structures & Civil
- Transportation
- Visualization



6

Engineering and Forensics

- **Engineer:** A person who uses science, math, and creativity to solve technical problems. They create, plan, build, or design a solution or a process.
- **Forensic Engineering:** A field that combines engineering, science, and law principles to investigate and analyze various types of failures or accidents.



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Forensic Engineering Technology

- High-resolution photography
 - Cameras, microscopes, and SEM (scanning electronic microscope)
- Unmanned aerial vehicles (drones)
- Accident reconstruction



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Forensic Engineering Technology (cont.)

- FARO scanning
 - Portable 3D measurement and digital imaging
- CT scanning
 - Evidence exam/preservation
 - Causes of failure




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Forensic Engineering Technology (cont.)

- Motion Capture (MOCAP)
 - Measure the three-dimensional full-body movement of a person in any environment
- 3D computer modeling & animation
- Illustrations and drawings



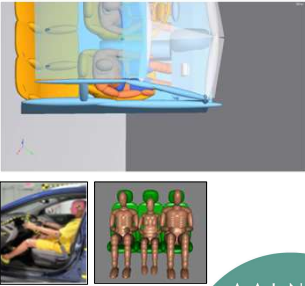
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Forensic Engineering Technology (cont.)

- **MADYMO** (Mathematical Dynamic Models)
 - Occupant safety system analysis; automotive/transport industries
- **ATD** (Anthropomorphic Test Devices)
 - Crash test dummies
 - Simulate human response to impacts/forces during a crash
- Science-based and admissible in trial



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Forensic Engineering Technology (cont.)

Example of physics-based animation



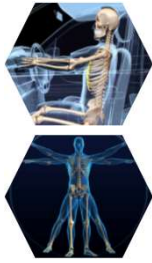
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What is Biomechanical Engineering?

- **Biomechanical Engineers:**
Study how motor systems create force and motion in biological systems or living organisms (Humans)
 - Explains how motions and forces correspond to injury
- **Those who can assist Forensic Biomechanical Engineers:**
 - Human Factors consultants
 - Forensic Nurses
 - Medical Doctors
 - Pathologists



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Biomechanics and Human Safety

- Apply scientific methods/engineering principles to a wide range of industries, products, and environments
 - Consumer products
 - Medical devices
 - Toys
 - Fitness equipment
 - Tools and construction equipment
 - Industrial machines
 - Hazardous substances and environments
 - Transportation industries



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Human Factors Analysis

- A broad field of study that deals with how humans interact with their perceivable environment
 - Psychological and physical aspects
 - Capabilities
 - Anthropometry (size and shape)
 - Strength, senses (sight, hearing)
 - Perception-reaction time
 - Conspicuity (quality of being clear or bright)
 - Medical issues (health, fatigue, stress)



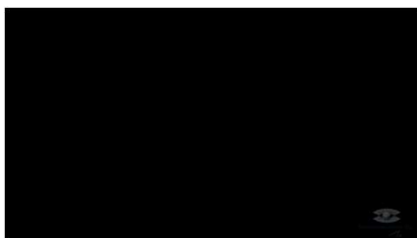
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Example of Human Factors

Demonstration of conspicuity



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Role of Forensic Nurse in Engineering

- Forensic Accident Record Review
- Review, analyze, and interpret medical records/investigation records
- Injury analysis/investigation
- Types of cases
 - Transportation
 - Slip and Fall
 - Construction and Industrial
 - Medical Devices
 - Product Safety
 - Fire & Explosion
 - Criminal



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Role of Forensic Nurse in Engineering (cont.)

- Main goal
 - Focus on evidence that may benefit the accident investigation
 - Assist in finding the missing piece to the puzzle
- Questions
 - Are injuries consistent with the incident?
 - What is their story?



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Case Study #1

Ice cream truck vs. pedestrian



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Case Details

- 34 yr. old female runner at her local gym went outside for a run
- Clear weather, dry road, daylight
- She was hit by an ice cream truck
- Undivided 2-lane road, speed limit 25 mph
- +LOC
- She did survive but had multiple significant injuries
- She could not recall anything from the accident
- No witnesses



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Case Details (cont.)

- **Client:**
 - Defense attorney for ice cream truck driver
- **Claim:**
 - The plaintiff claimed the ice cream truck was at fault along with pain and suffering
- **Scope:**
 - Accident reconstruction and human factors analysis
- **Questions:**
 - When/where exactly did the accident occur?
 - What were the paths?
 - What was the point of impact?

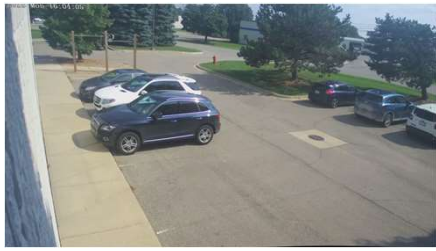
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Security Video

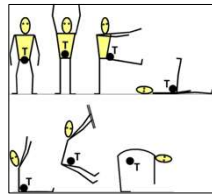
The most important part of the video from the gym is missing?



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Medical Record Analysis

- How did the Forensic Nurse assist?
- Medical record summary
 - What were her physical injuries?
 - What was her story?
- Injury diagram
 - Focus on contact points from the ice cream truck
 - Assisted with determining positioning on impact and trajectory of her body



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Medical Record Analysis (cont.)

Injury Diagram

Diagram Key
 Fracture
 Hemorrhage/Laceration/
 Abrasion
 Contusion
 Tear/Dislocation
 Bruise
 Hematoma

Labels:
 L temporal contusion/bruise
 Left scalp hematoma
 L upper arm abrasion
 Left 4th finger pain/hand pain
 L anterior thigh abrasion/pain
 LLE large lacerations
 -L lower leg/skin abrasion
 -Large abrasion below knee
 L anterior foot abrasion
 R knee pain
 R medial pneumothorax
 Chest/sternum pain
 Large R knee lacerations (open wound)
 R tibial tuberosity abrasion
 R lower leg road rash/laceration
 R shin abrasion
 R ankle/malleolus abrasion (open wound)

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Medical Records Analysis (cont.)

Injury Diagram

Diagram Key

- Fracture
- Hemorrhage/Laceration /Abrasion
- Contusion
- Tear/Dislocation
- Bruise
- Hematoma

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Biomechanical Analysis Technology

- Accident site and vehicle inspection
 - Photographs, measurements, laser scans, and aerial (drone) photography
- Surrogate testing (female jogger)
 - MOCAP
- Accident reconstruction
 - Time-distance analysis

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Biomechanical Analysis Technology (cont.)

- Human Factors Analysis
 - Sightline and perception-reaction analysis
- Generation of 3D animations
- Surveillance video and physical evidence
 - Analyze kinematics (paths, speed, etc.) for the ice cream truck and pedestrian

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Accident Reconstruction

Time/distance analysis



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3D Animation - Driver's View

Exhibit used in mediation



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3D Animation - Overhead View

Exhibit used in mediation



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Biomechanical Analysis Conclusions

- Before the incident
 - Ice cream truck traveling east ~ 34 mph
 - Pedestrian was running east along the edge of the pavement at ~8 -10 mph
- At the time of impact, the pedestrian was attempting to cross from **Left to Right**
- The pedestrian failed to scan her surroundings and/or establish a direct line of sight to the ice cream truck before crossing the roadway



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Biomechanical Analysis Conclusions (cont.)

- The sudden/unexpected change in direction of the pedestrian decreased the ice cream truck driver's ability to respond or perceive the nature of the situation in a timely fashion
- Earbuds diminished any auditory signals produced by approaching ice cream truck
- Outcome
 - Settled in mediation



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Case Study #2

Vehicle Support Collapse Accident



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Case Details

- 21-year-old male trapped underneath a car
- Mother found decedent in garage
- Father jacked up the vehicle off the decedent and called 911
- Ratcheting jack stand(s) and pump jack stand were found at the scene
- Fatal injuries occurred



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Case Details (cont.)

- **Client:** Defense attorney for jack stand manufacturer
- **Scope:** Investigate the incident and perform geometric analysis and accident reconstruction
- **Claim:** The decedent was using a jack stand to support the front end of a motor vehicle to change the oil when the jack stand failed and collapsed
- **Question:** Was the plaintiff's allegation supported by the evidence, or was another explanation more likely?



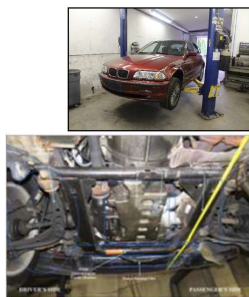
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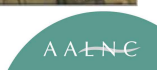
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Biomechanical Analysis

- Inspections of accident site and subject vehicle
- Measurements of the incident location, the subject vehicle, exemplar equipment, and allegedly involved components
- Laser scanning
- Exemplar vehicle and equipment testing
- Animated computer models and stills



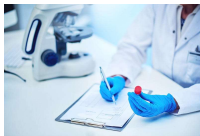
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Medical Record Analysis

- How did the Forensic Nurse Assist?
- Review Autopsy:
- External findings:
 - Petechia about-face and conjunctivae
 - Congestion about the upper portion of the body
- Lungs: Hyperinflated
- No documentation of other external injuries
 - Poor pathology report
- COD: Traumatic asphyxia



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Medical Record Analysis (cont.)

- Documented all physical injuries:
 - Abrasion in the center of the sternum
 - Bruising near the collarbone
 - Abrasions to the right side of the face
 - Linear mark to the right of the decedent's navel
 - Abrasion along the right side of the torso



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3D Injury Animation



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Injury Analysis

- Stabilizer Bar
- Passenger side of the power steering line
- Collar on the power steering line
- Component of engine cradle
- Wooden creeper structure supporting body
- Underside of components of front bumper

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Opposing Expert Analysis

- Opposing expert "jack stand" hypothesis
 - >The vehicle had been solely supported by a single jack stand beneath the front passenger side frame member, which then collapsed/tipped over
- Why this is NOT true
 - >This is not supported by any physical evidence to the decedent
 - >The jack stand location exhibited substantial interference with the decedent's known position/configuration

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Exemplar Vehicle/Equipment Testing

- Lifting pad damage
- Witness marks on rocker panel

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Biomechanical Analysis/Conclusion

- ESI's "pump jack" hypothesis:
 - The vehicle had been elevated and supported solely by the pump jack and subsequently dropped, trapping the person beneath certain structural components
 - No additional safety measures were utilized



- Outcome
 - Settled in mediation

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Case Study #3

MVA: Motorcyclist v. Sedan



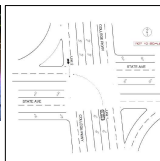
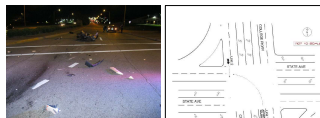
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Case Details

- Time of accident 9:00pm
- Both approaching same intersection
- Motorcyclist stopped at the red light then proceeded to travel straight through intersection after the green light
- Sedan proceeded to turn left and struck motorcycle in the intersection
- Motorcyclist suffered critical injuries



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Case Details (cont.)

- **Client:** Defense attorney representing Alcohol Monitoring System bracelet company
- **Scope:** Accident reconstruction and biomechanical analysis of LE injuries sustained by motorcyclist
- **Claim:** The Alcohol Monitoring System ankle bracelet he was wearing contributed to his left leg injuries
- **Question:** Did the Alcohol Monitoring Bracelet worsen the LLE injuries from the motorcycle crash?



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Accident Reconstruction Analysis

- The front of the sedan contacted the front and left sides of the motorcycle
- Due to the impact, the motorcyclist's upper body contacted with the hood and windshield of the sedan
- The plaintiff was separated from his motorcycle and landed on the ground, away from the point of impact



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Medical Record Analysis

- **How did the Forensic Nurse Assist?**
- Motorcyclist injuries:
 - Concussion
 - C5 burst fracture
 - Traumatic spinal cord injury
 - Severe open and comminuted fractures of left tibia and fibula w/ significant soft tissue injury (disruption/loss)



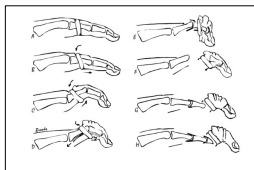
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Biomechanical Injury Analysis

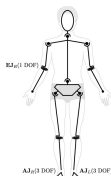
- Opposing experts were claiming that the bracelet caused a "ring avulsion" type injury
 - The injuries were consistent with direct impact, so kinematics did not make sense



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Biomechanical Injury Analysis (cont.)

- Injury Kinematics
 - The bumper of the sedan aligned with the approximate location of plaintiff's lower left leg
 - The damage on the two vehicles is consistent with the front bumper of sedan contacting plaintiff's lower left leg
 - Bracelet positioned just above plaintiff's left ankle below the point of impact
 - Most of soft tissue injury was proximal on plaintiff's leg relative to the bracelet
 - Expect bracelet to move distally towards the foot as plaintiff was propelled upwards and away from bike



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Biomechanical Analysis Conclusion

- Conclusion
 - The lower extremity fractures/soft tissue injuries are consistent with direct contact by front bumper of sedan and associated compression of leg between the sedan/motorcycle
 - The alcohol monitoring bracelet DID NOT contribute to the injuries



❖ What else did the Forensic Nurse find?



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Medical Record Analysis

- Looked at time stamp of records
 - 9:19 pm, Arrived at ER
 - 9:35 pm., X-ray/LLE (<20 minutes later)
 - *Alcohol Monitoring Bracelet was not documented in report*
- Requested radiology films; noticeably ABSENT from X-ray/LLE
- Ankle bracelet was ONLY mentioned in a nurse's note at 2:40 am (>5 hrs. later) that described long process of removing bracelet from plaintiff's leg for MRI/cervical
 - Which leg was not documented?



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Additional Information

- Client sought out information to verify the bracelet's location
 - 12:00 am, the bracelet's transmitted body temperature data showed a distinct change in temperature which would occur when separated from the body
- High-quality photos of the bracelet taken shortly after the accident showed no damage or blood



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Conclusion & Takeaways

- Conclusion
 - Evidence ALL consistent with the alcohol monitoring bracelet being on the UNINJURED right leg
- Outcome
 - Plaintiffs dismissed the case and fully walked away
- Takeaways:
 - Review radiology images, not just report!
 - No one thought to review the actual radiology images alongside medical chronology
 - Question everything and triple check details
 - Numerous attorneys/several physicians reviewed the case/associated file material
 - No one prior to ESI's involvement thought to question the location of bracelet or considered the uninjured leg

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Case Study #4

Fall off retaining wall



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Case Details

- Time of incident: 11:00 pm
- 45 yr. old female had been out drinking at night with friends, walking home alone from a pizza restaurant
- Fell over a retaining wall located on the property of a local company
- She was attempting to take an unfamiliar short cut to her home
- No LOC, found 6 hrs. later
- Significant injuries to BLEs



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Case Details (cont.)

- **Client:** Defense attorney for local business company
- **Scope:** Conduct biomechanical analysis related to a fall in the area of a retaining wall
- **Claim:** Plaintiff stepped off an unmarked unsecured unreasonably dangerous ledge/drop-off in a parking lot
 - Plaintiff was not aware of the dangerous condition and there were no signs or warnings
- **Question:** Are the injuries consistent with the claimed fall?

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Scene Inspection Photos



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Medical Record Analysis

- How did the Forensic Nurse assist?
- BLE injuries:
 - Right ankle deformity
 - Minor laceration/abrasions to both feet
 - Multiple fractures and dislocations of the left foot (Lisfranc fracture dislocation of the midfoot)
 - Fractures of her right distal tibia/fibula
 - Right ankle pilon fracture
- No injuries above LE'S (RED FLAG!)



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Medical Record Analysis (cont.)

- Various incident descriptions:
 - She did not realize that she had walked up to a retaining wall, she fell and landed feet first
 - Walked off ledge overnight, fell 10 ft. landed on feet
 - Fell approximately 12 ft. from a ledge
 - She landed on her bilateral ankles



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Plaintiff Deposition

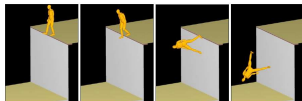
- Incident descriptions:
 - Did not notice the retaining wall or see retaining wall bricks at all while she was walking
 - "Pitch dark" at the time
 - Looking straight ahead and did not look down
 - Did not trip, but stepped over the retaining wall and stepped into "nothingness" and fell forward because there was nothing to support her stride
 - Fell "straight down" and had both feet hit together
 - Denied that she tried to jump down the retaining wall



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Biomechanical Gait Analysis

- Her story:
 - "Fell straight down and landed on both feet together."
 - This expected fall kinematic is NOT consistent with her statement
 - Given dimensions of exposed retaining wall and her expected gait characteristics, unlikely that she could have stepped over retaining wall without interacting with it...into "nothingness"
 - Expect head/arm first landing! No way she could land on both feet!



- MADYMO simulation of a step off of a 10-foot retaining:
 - Leading legs falls
 - Trailing leg still in contact with ground
 - Body pitches forward
 - No leading leg support
 - Center of gravity moves out of base of support
 - Forward fall



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Biomechanical Gait Analysis (cont.)

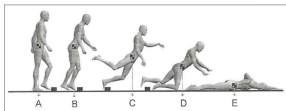
- Per deposition, she did not trip and did not indicate that anything interfered with stride
- If walking forward towards retaining wall, she would have likely encountered two locations that would have interfered with the swing phase of her gait
 - The curb
 - A portion of the retaining wall



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Biomechanical Gait Analysis (cont.)

- The likely encounter of the two possible locations would likely initiate a trip causing her body to fall forward
- Expect head or arm first landing, no way she could land on both feet!



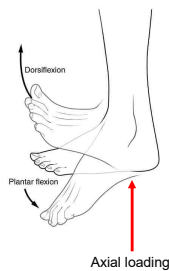
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Biomechanical Analysis/Injury Analysis

- Lisfranc fractures of midfoot is axial loading while the foot is in plantar flexion
- Pilon fracture pattern occurs due to axial loading of tibia and fibula up through the foot
 - High energy fractures; common for falls/jumps from a height where the feet impact the ground
 - Her injuries require loading up through the bottom of both feet which is consistent with her testimony
 - She "fell straight down" and "both feet hit together"



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Biomechanical Analysis Conclusions

- Numerous artificial light sources present in the area
- Fall kinematics and injuries are NOT consistent with trip or misstep over retaining wall
- Her described fall kinematics and injury pattern ARE consistent with an attempted hop or jump down from top of retaining wall
- Outcome: Settled before trial





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Questions?





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