Background

- Household falls are a common accidental injury mechanism as well as a common falsely reported cause in cases of abuse.
- In non-ambulatory children, femur fractures are more likely to be due to abuse.
- Clinicians must be able to delineate between abuse and accidental injuries.
- Currently little biomechanical evidence to distinguish accidental and non-accidental injuries.

Objective

- Develop an in-silico femur model
- Evaluate stress and strain distribution in the femur during a bed fall
- Evaluate different material applications to the in-silico model and their effect on outcomes

Methods

- A post-mortem diagnostic CT scan of a 11-month-old was used to derive a 10-node tetrahedron femur model (ANSYS) meshed in 3-matic (Materialise, Ann Arbor MI). (341736 elements)
- Used phantom-less calibration to define relationship between HU and bone mineral density
- Analyzed in ANSYS Workbench (ANSYS Inc., USA) (Figure 2) using applied femur loads and constraints similar to those in bed fall experiments. Simulation of falls for each impact surface were evaluated.
  - Peak values of the applied forces and moments can be found in Table 1.
  - ATD strain gauge outputs were used to compare two distal femur constraint scenarios (Figure 2b and 2c) using the linoleum loading conditions.
  - Evaluated 3 different material application approaches in the model using Mimics (Materialise, Ann Arbor MI).
    - 10 and 50 bins, equally distributed across span of HU values
    - 2 bins: Median HU of the cortical and trabecular segments applied to their respective regions

Results

- Fixed intercondylar region constraint setup had a better agreement with the ATD’s strain gauge output.
  - This setup was used in the evaluation of biomechanical outcomes of the bed falls
  - Linoleum and carpet surface resulted in similar outcomes
  - The maximum principal strain occurred at the proximal lateral end for both surfaces
  - 50 bin and 10 bin application resulted in similar outcomes
  - The maximum principal strain in the 2 bin application was consistently lower
  - Limitations: Only considered stress and strain values of the femur shaft to be consistent with ATD load cells.

Conclusions

- Both conditions resulted in similar outcomes suggesting similar risks of fracture.
- The 10 bin model would be adequate to evaluate future loads since it is similar to the 50 bin.
- Reduced number of bins is preferable
- Future work:
  - Application of remaining ATD femur loads
  - Further mechanical validation of the model