A Detailed Study of Real-World, High Tibia Impact Injury Data for Comparison with Biomechanical Research Findings

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Background

Serious injuries sustained to the Knee Thigh Hip (KTH) complex during frontal impact motor vehicle accidents (MVAs) are a strikingly significant health concern in this country.[1,6,9,10] Due to this, a progression of research projects have developed dynamic impact testing devices that have been used to characterize Injury criteria data for the lower extremities and the KTH. [2,3,4,5] Work currently under way at The Ohio State University IBRL (Injury Biomechanics Research Laboratory) is attempting to perfect the dynamic testing apparatus and produce a final, accurate characterization of the lower extremity injury criteria using dynamic simulated impacts with Post Mortem Human Subjects (PMHS/cadavers). This data may be used to build more realistic anthropomorphic testing devices (crash dummies) so that car manufacturers can ease morbidity rate with safer passenger compartment designs. The IBRL has shown a serious need, however, for real world injury data to compare with and validate data elucidated in the lab. Unfortunately, national trauma databases like CIREN, CDS and NASS and the current trauma literature that is almost completely based upon them do not carry sufficient data on the ligament injuries (PCL) being characterized by the lab; thus it was uncertain if accurate simulations of real world injuries were taking place.[6,7,8,9,10] This project thus strove to fill that need by compiling data through previously untapped resources.
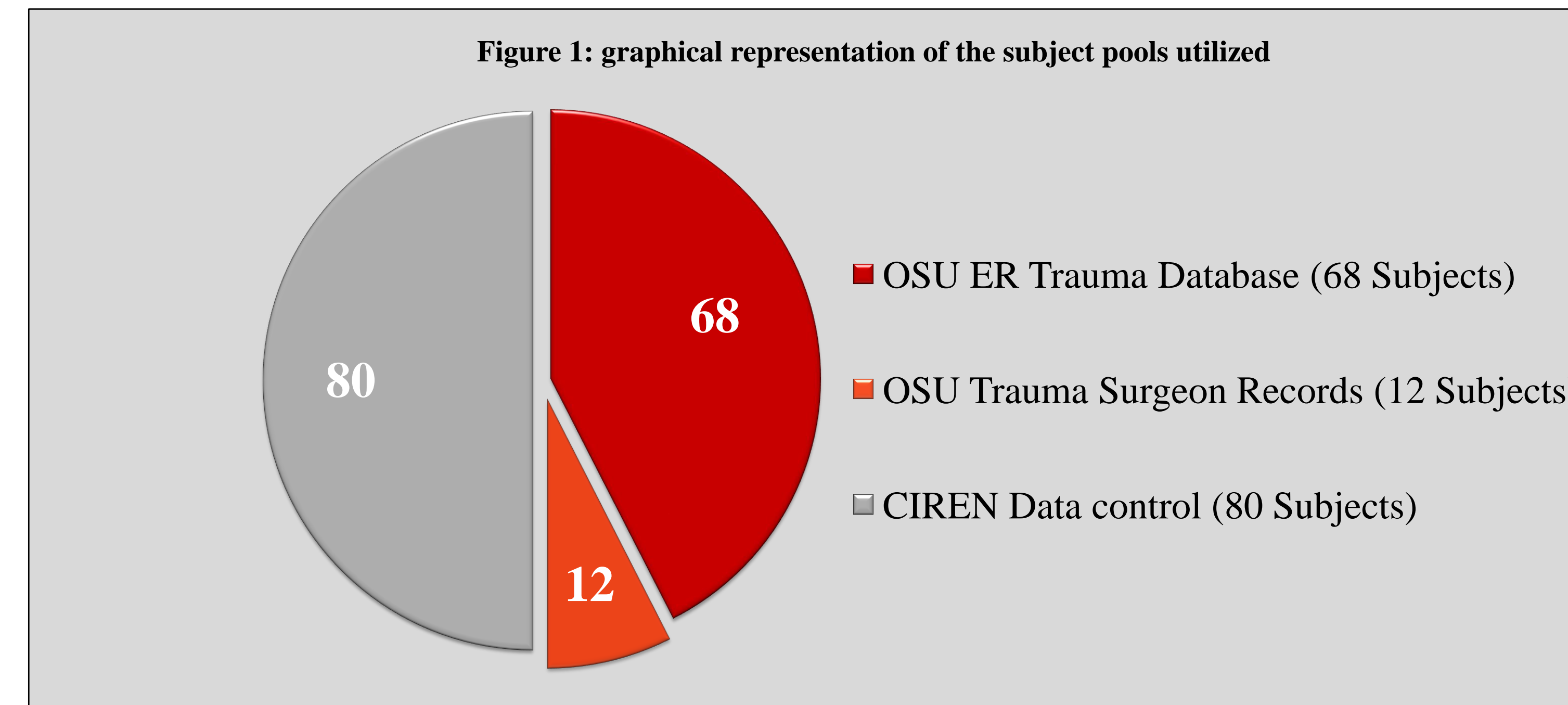
Objective

- Compile KTH injury data from OSU trauma resources
  - OSU trauma database, OSU trauma surgeon medical records
  - Search for prevalence/existence of Ligament/Tendon/Cartilage Injury Data
- Compile National Database (CIREN) and literature injury data
  - Create comparison-control subject pool
- Compare Findings
- Determine if the IBRL data correlates to real-world injuries and/or determine if the national databases and literature are under-representing Ligament and other soft tissue injury.

Methods

Establishing Search Criteria for OSU and CIREN data

- Vehicle Make, Model, Year – All inclusive
- Impact Criteria
  - Frontal Impact (10 o'clock to 2 o'clock from central axis)
  - Impact with second vehicle, tree, median, barrier, etc.
  - Rollover /Multi-vehicle accidents excluded
- Subject Criteria
  - Age: 15-85
  - Gender: Male and Female
  - No major health history problems (OSU data only)
- Restraint Criteria
  - Safety Belt Use Required (manual or automatic belts)
  - Airbag availability and Deployment optional
- Injury Criteria
  - Fractures, Ligament/Tendon/Cartilage Avulsion Fractures, tears, dislocations
  - Superficial lacerations, contusions, abrasions all excluded
  - All Strains and Sprains and Muscular injuries excluded.
  - Regional KTH Injury classifications developed for tabulation (see Table 2, 3)
  - Sub-regional Injury classifications developed for further sorting (see Table 4, sub-reg not shown for other injury types)

Subject Pools

Figure 1: graphical representation of the subject pools utilized

- OSU ER Trauma Database (68 Subjects)
- OSU Trauma Surgeon Records (12 Subjects)
- CIREN Data control (80 Subjects)

All subjects depicted above were selected based on eligibility under the selection criteria described under Methods. The Primary Subject pool (in red tones) consisted of Ohio State University Medical Center patients involved in a frontal impact MVA. 68 subjects were identified within the OSU emergency department's trauma database that matched the study criteria. Another 12 trauma subjects that were current, or recent, patients of OSU surgeons were also utilized. All data was taken from Electronic Medical records or Paper records in a retrospective manner. To serve as a comparison control, 80 subjects were also selected from the public version of the CIREN trauma database using identical criteria (in gray tones).

IBRL Test Apparatus

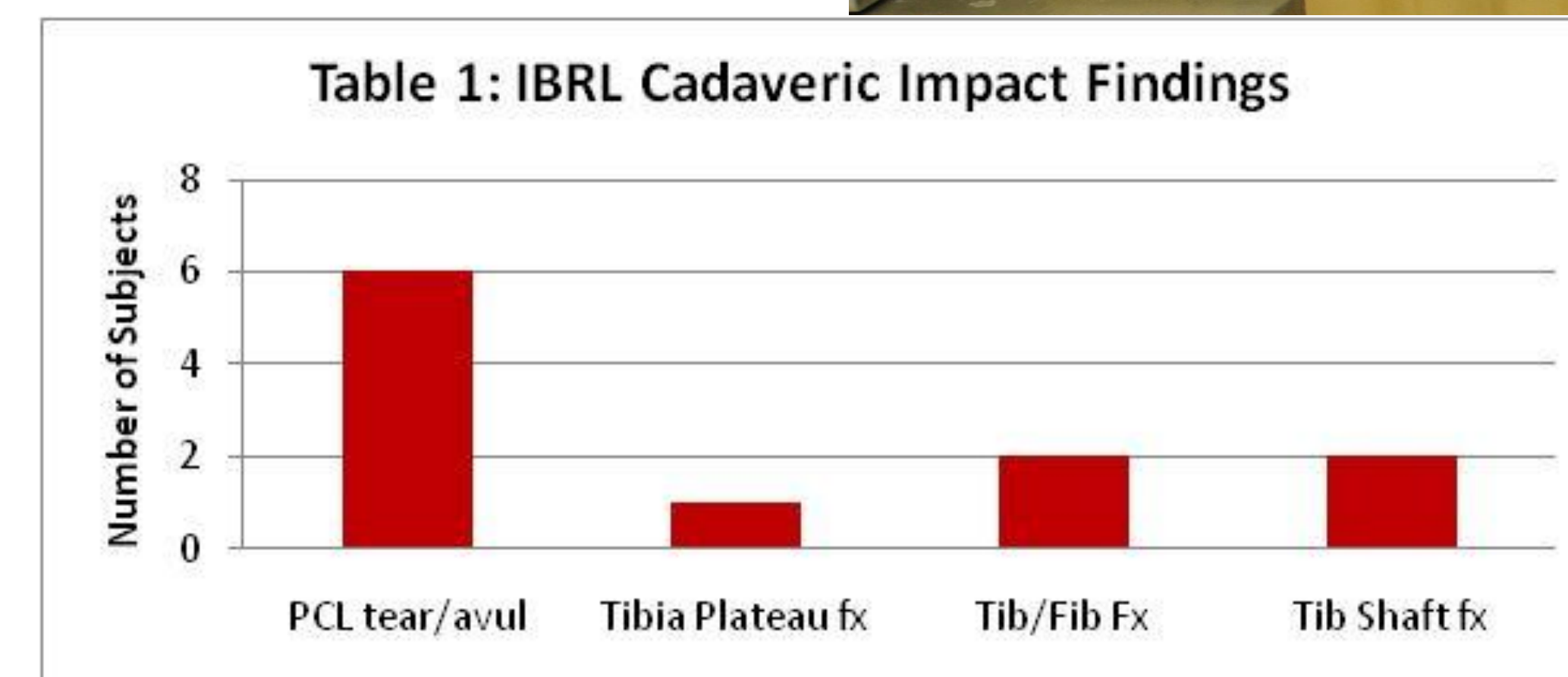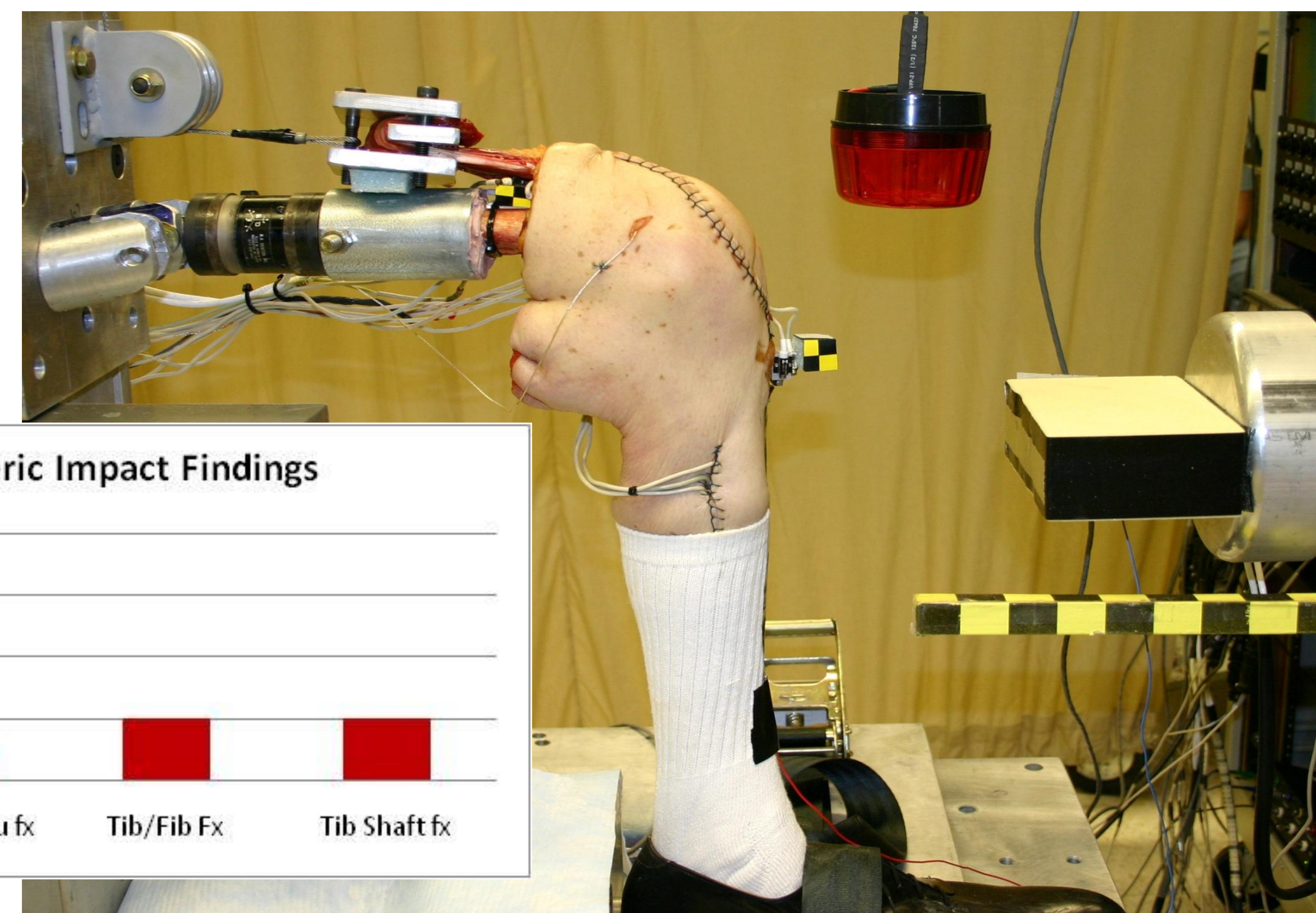
Table 1: IBRL Cadaveric Impact Findings

Figure 2: IBRL dynamic impact testing apparatus with PMHS mounted. Data from this apparatus was used to construct Table 1. This table depicts the four injury types encountered during IBRL testing. The prevalence of PCL injuries in particular and the fact that ligament injuries were found to be poorly characterized in national databases and trauma literature were prompting factors for this study.

Results and Discussion

Figure 3: Clinical Model Pool

Figure 4: Engineering Model Pool

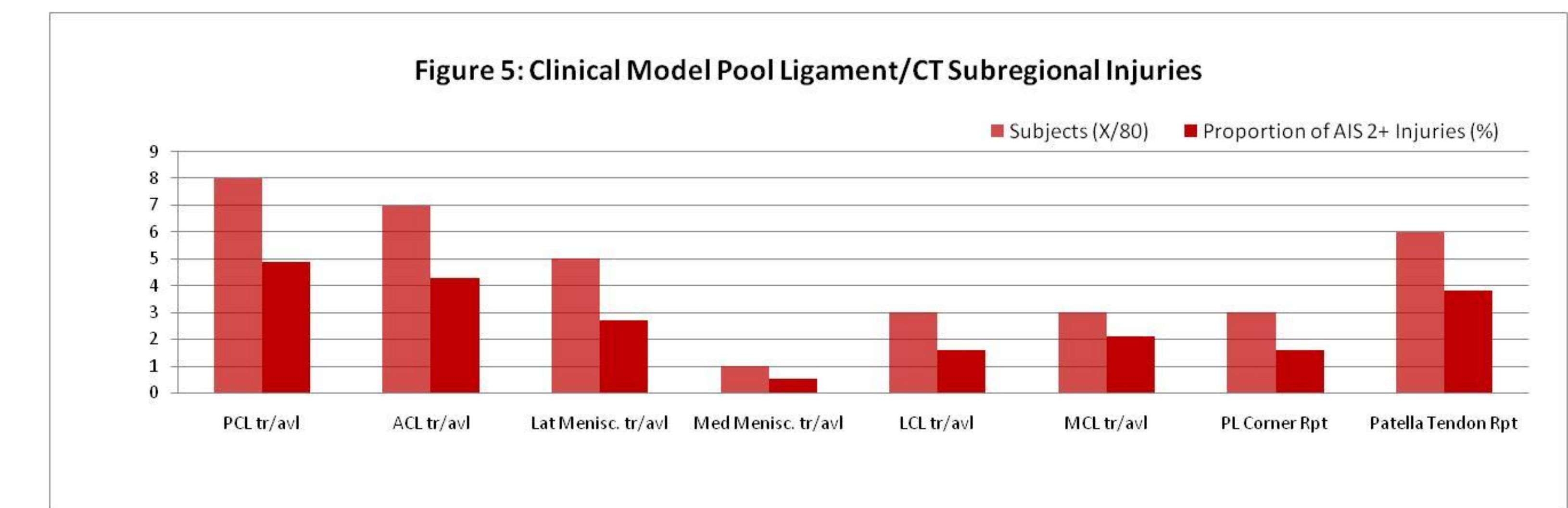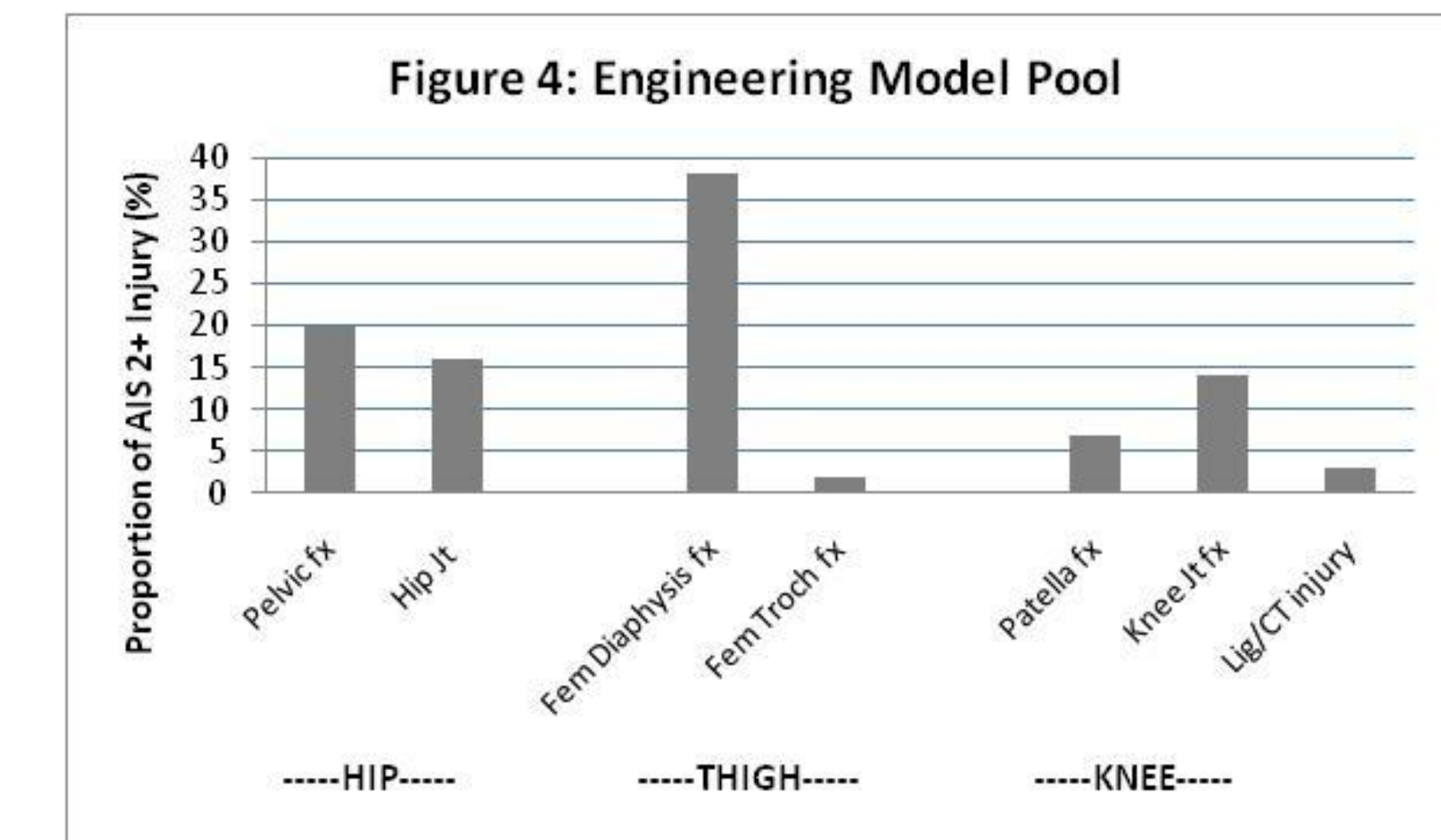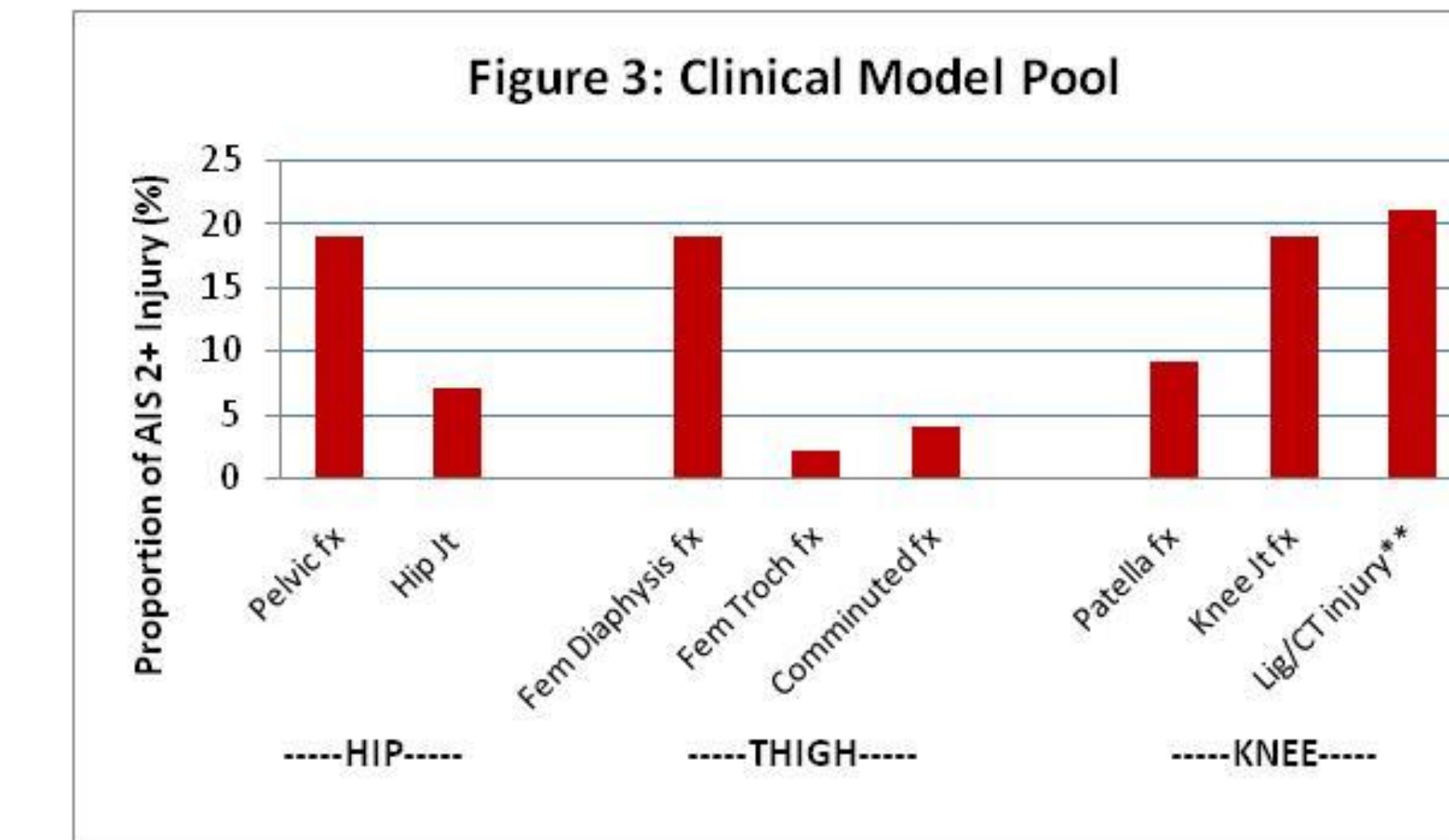Figure 5: Clinical Model Pool Ligament/CT Subregional Injuries

Figure 3 above shows the results for the six major KTH regional injury types found in the OSU primary subject pool. Figure 5 depicts the major ligament and cartilaginous injuries discovered in noteworthy numbers in the primary subject pool. These correlate with IBRL findings shown in Table 1 (especially prevalence of PCL injury in frontal impacts). Note that both the CIREN data in Figure 4 and literature example in Figure 6 (Kuppa et al[10], gold standard NHTSA study based on CDC and NASS data) report ligament injury occurrence at a much lower rate than that found in the primary subject pool. These sources also provided no detail or clarification as to which ligament or tendon was injured when reports were made.

Figure 6: Engineering Literature Characterization of KTH Injuries [Kuppa et al]
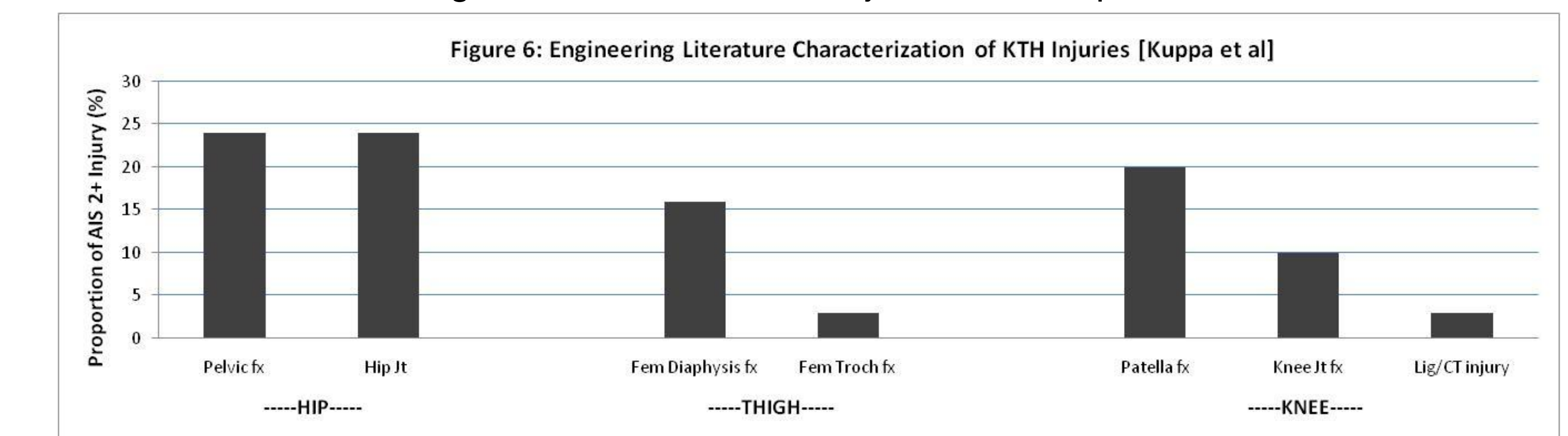
Conclusions

- Real world injury findings support IBRL testing data. PCL injury found to be prevalent in frontal impact MVAs.

- Serious knee ligament, tendon, and cartilage injuries are occurring at much higher rates than what has been reported in national trauma databases and trauma literature. Based on prevalence (relative to other KTH injury categories), reporting of ligament injuries may be indicated in future publications.

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