

Impact Testing of a Proximal Femur in a Fall Configuration

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ABSTRACT

Hip fracture risk is generally estimated using DXA, and while effective for identifying individuals at extreme risk, it has proven ineffective for identifying the majority of those at risk of hip fracture (1). Mechanical and computational testing of proximal femurs have been previously carried out, however have been limited by low loading rates and insufficient modelling of surrounding tissues (2-6). We hypothesized that fractures may have a mechanical etiology that can only be observed in physiologic impact tests, replicating all the elements of a fall: rate, energy and surrounding structures. In this test we used a drop tower to impose an impact force to a human femur oriented in the standard fall positioning. One cadaveric femur was painted with a speckle pattern and mounted statically in our drop tower. Using a standard fall position (3), the femur was impacted on the trochanter by a 16.5 kg mass travelling 3.5 m/s (7), in this case, surrounding tissues were not modelled (Fig 1). The impact was observed using high-speed (HS) imaging at 9000 frames/second and a 6-axis load cell collected forces on the trochanter at 90 kHz. The HS images were analyzed using digital image correlation (DIC) (LaVision, Germany) and a map of minimum principle strain was overlaid on the surface. A physiologic fracture was observed and the progression of the crack was seen in the high speed video and DIC. The DIC identified the locations of fractures and generalized yielding. A peak force of 3800 N was observed at 6.99 ms after initial contact (Fig 2). A physiologic fracture was created, however the impact duration and initial crack location were influenced by the omission of surrounding tissues. In future tests, the pelvis and trochanteric soft tissues will be simulated to improve the impact characteristics and 3D-DIC will be used.