## D3 Specimen Age Affects the Fracture Pattern of Immature Porcine Femurs Under Torsional Loading

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After attending this presentation, attendees will better understand the influences of bone development and rate of twist on torsional failure characteristics of porcine femurs.

This presentation will impact the forensic science community by providing additional information on the use of fracture ratio to help differentiate Accidental Trauma (AT) from Non-Accidental Trauma (NAT) under torsional loading scenarios.

In the current forensic literature, differentiation between an abusive and accidental trauma in children less than three years of age remains challenging. Currently, it is assumed that any trauma incurred by children less than three years of age is frequently NAT, and that any trauma in children less than one year is always NAT.[1] Furthermore, spiral long-bone fractures in young children are challenging cases because there are limited "ground truth" data to help forensic investigators determine the mechanisms of long-bone fracture. A recent study has proposed fracture ratio, defined as the fracture length in a lateral radiograph over the diameter of the bone, to help distinguish NAT from AT. The study has associated small fracture ratios (≈1.6) with NAT and large ratios (≈2.8) with AT.[2] Another study using an immature canine model indicates that the fracture ratio is increased for a high rate of bone twist.[3] The authors of that study assume AT occurs at a high rate of twist while NAT occurs at a low rate; however, it is currently unclear if age is a covariate of the facture ratio generated under a torsional load.

The purpose of this presentation is to: (1) present new data on torsional fracture ratios using an immature porcine model; (2) examine the effect of age on the fracture ratio; and, (3) examine the effect of age on the rate of twist sensitivity in fracture ratio.

Thirty-six immature porcine femurs aged 1-17 days were twisted to failure in a servo-hydraulic machine using a custom-built torsional loading fixture. Twenty-two specimens were twisted at a low rate ($3°s^{-1}$), among which 14 specimens were from a young age group (1-9 days) while 8 specimens were from an older group (10-17 days). These age groups were previously defined by Powell et al.[4] Fourteen additional specimens from the young age group were twisted to failure at a high rate ($90°s^{-1}$). All specimens were frozen at -20°C within 12 hours of natural death. Specimens were thawed at room temperature and tested within 48 hours. The bones were kept moist with saline solution during all preparations and experimentation. The bone ends were potted in cups with room-curing dental cement. Specimen lengths were maintained at 3.10 ± 0.44 times the smallest diameter of each bone, as measured with calipers. The fracture ratio was determined post-failure.

The study demonstrated that for bone specimens from the young group, the fracture ratio increased linearly with age for both the high and low rates of twist. For the older group of specimens twisted at a low rate, there was no significant effect of specimen age on fracture ratio. For the young group of specimens, the fracture ratio generated in the high rate of twist experiments was consistently 1.3-1.4 times that generated in the low rate of twist experiments across all ages (1-9 days). An analysis of fracture surfaces showed alternating planes of transverse and longitudinal oriented fracture to be varied with age that directly related to changes in fracture ratio.

A previous study in the biomechanical literature suggests that the helical fracture pattern often characterized after torsional loading of a long bone is due to a combination of tensile and longitudinal shear failure.[5] It has also been shown that the tensile strength of bone typically increases with age and rate of loading.[6,7] Based on the previous biomechanical literature, the results of the current study suggest that the increase in fracture ratio documented with specimen age may be due primarily to an increase in tensile strength of the bone with age and rate of twist. Additional studies will be needed to support these hypothesized changes of tensile and longitudinal shear strength with specimen age for this long bone. A better understanding of these long bone fracture characteristics may be paramount as they may have significant implications in the interpretation of fracture ratio to be used in differentiating NAT from AT in children.





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**Pediatric Abuse, Fracture Pattern, Animal Model**