Use of Osteon Circularity to Determine Species Affiliations can be Confounded by Habitual Load Complexity

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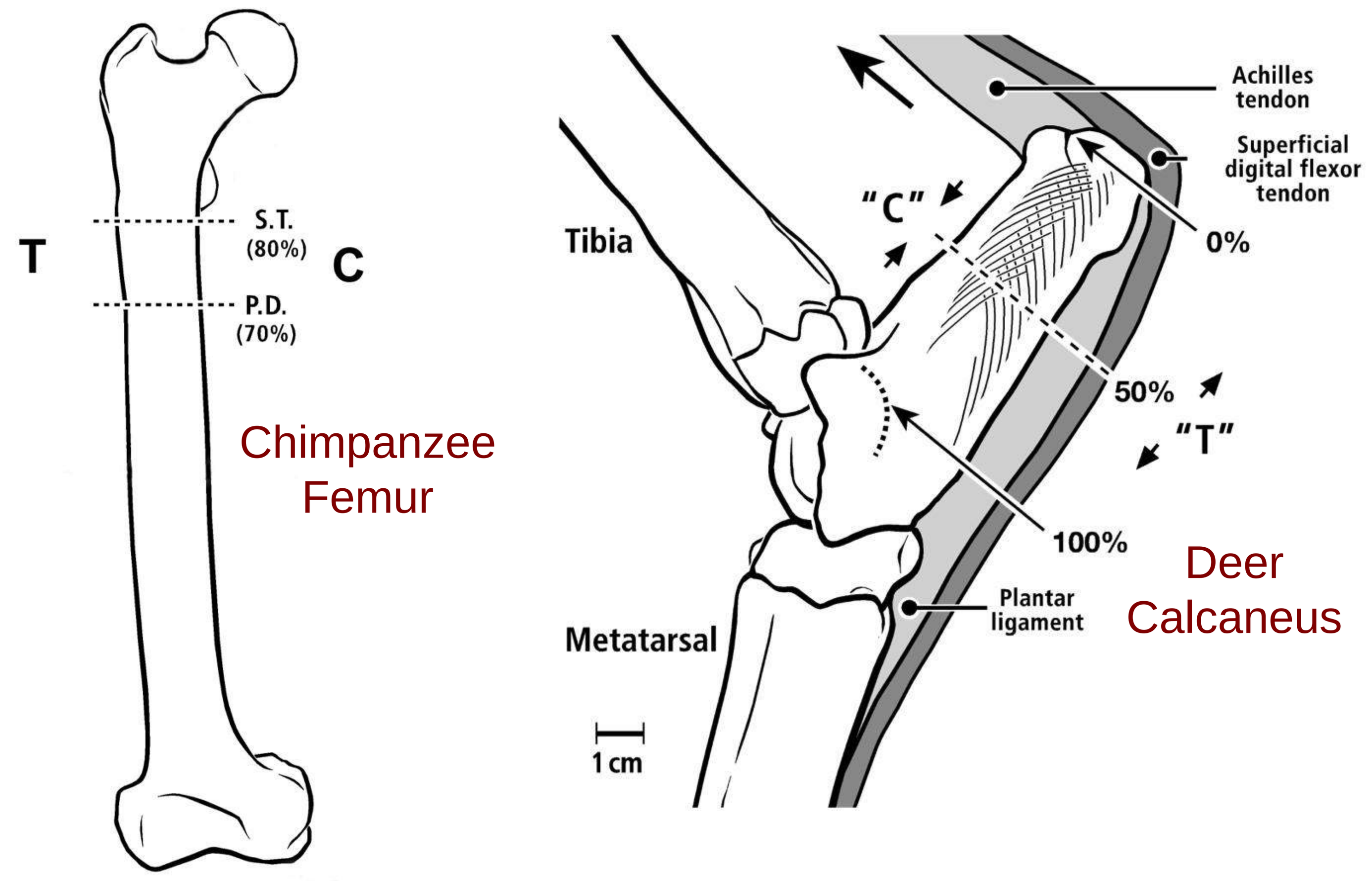
Introduction

Osteon circularity (On.Cr) is potentially useful for studying load history in limb bones, and for distinguishing high complexity loading (e.g. torsion+bending) from simple complexity loading (e.g. unidirectional bending). On.Cr is also useful for determining species affiliations. We hypothesized that load complexity influences On.Cr in ways that can confound species determinations.

Methods

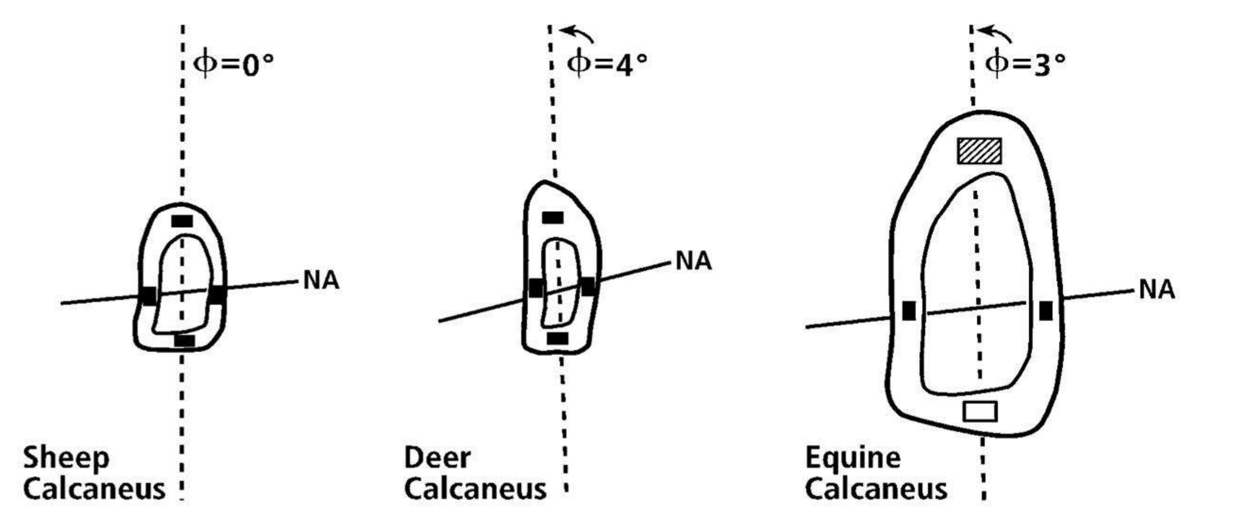
Using ImageJ we examined bones representing a spectrum of load complexities: low, intermediate-A, intermediate-B, and high. Specimens included mature: (1) sheep, deer & equine calcanei (simple), (2) sheep & equine radii (intermediate-A), (3) human,chimpanzee femora at proximal shaft, & equine third metacarpals (intermediate-B), and (4) sheep tibiae (high); n=7/each non-primate; n=8/chimpanzee; n=12/human (25-71yrs; avg. 53 years; 22-71; male : female = 3:9). All images were obtained in CPL. Statistical methods included: (1) one-way and three-way ANOVAs, and (2) discriminant function analysis (as done by Dominguez and Crowder, 2012, AJPA). Correlations were also conducted to determine relationships between On.Cr and osteon % area and osteon population density.

Examples of Section Locations

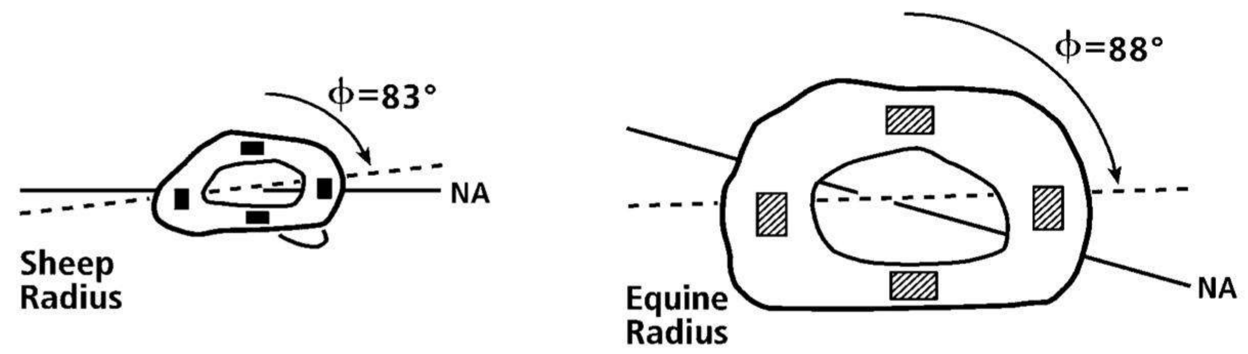


Cross-Sections of Non-Primate Bones Analyzed

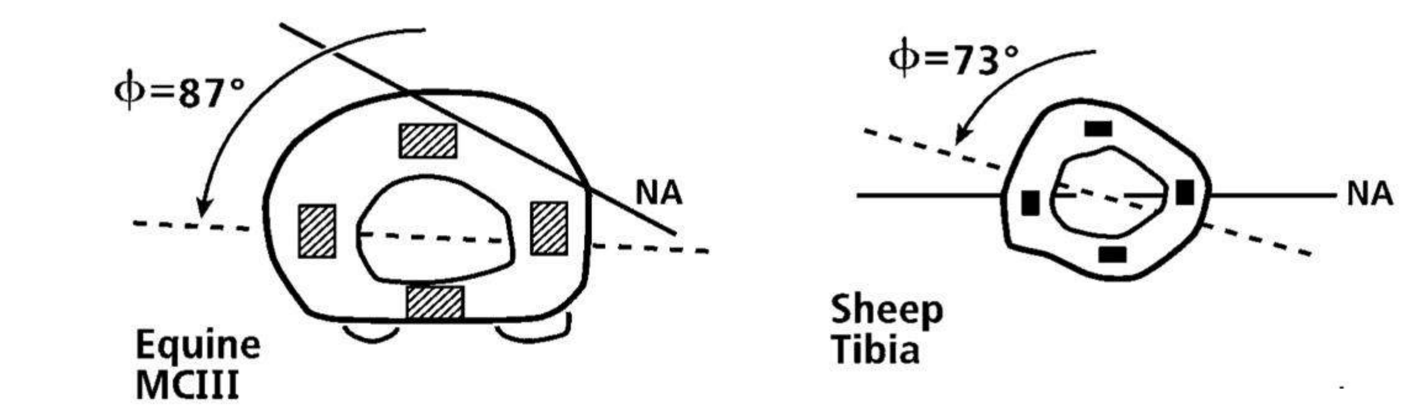
Simple Complexity Loads



"Moderate A" Complexity Loads



"Moderate B" Complexity Loads **High Complexity Loads**



Results

Results showed that even in the "simple" category, differences in On.Cr based on regionally habitual (prevalent/predominant) strain-mode (tension, compression, neutral axis) are inconsistent: only 3 of 9 bones that can be considered in this context showed significant differences for habitual tension vs. compression regions (see lower right). Additionally, On.Cr based on load-complexity category was inconsistent, as shown in both sheep and horse bones: statistically significant differences were found between load-complexity categories of the sheep bones but not the equine bones. Consequently, a fragment of a sheep tibia could inadvertently be identified as being a horse bone.

With respect to determining species affiliation, only human femora could be reliably distinguished from other species *but <u>not</u> in all cases*. Discriminant functional analysis showed that the percent classified correctly was highest in human (~80%) and much less so for all other bones (range: 6% chimp to 45% sheep) [see graphics at very bottom of this poster].

Correlation Analyses (R values)

	On.N/T.Ar vs. On.Cr.	On.N/T.Ar vs. On.A/T.Ar	On.N/T.Ar vs. ellipticality	On.Cr. Vs. On.A/T.Ar	On.Cr vs. ellipticality
All Osteons	0.42 (<0.001)	0.57 (<0.001)	NS	NS	-0.55 (<0.001)
Compression	0.33 (<0.001)	0.33 (<0.001)	NS	NS	-0.62 (<0.001)
Tension	0.27 (<0.001)	0.45 (<0.001)	NS	NS	-0.54 (<0.001)
Neutral Axis	0.47 (<0.001)	0.70 (<0.001)	NS	NS	-0.66 (<0.001)
Sheep Calcaneus	NS	0.76 (<0.001)	NS	NS	-0.90 (<0.001)
Compression	NS	NS	NS	NS	-0.95 (<0.001)
Tension	NS	NS	NS	NS	-0.90 (<0.001)
Neutral Axis	NS	0.81 (<0.001)	NS	NS	-0.93 (<0.001)
Deer Calcaneus	NS	0.87 (<0.001)	NS	NS	-0.74 (<0.001)
Compression	NS	NS	NS	-0.67 (0.033)	-0.71 (0.020)
Tension	NS	NS	NS	NS	-0.86 (0.002)
Neutral Axis	NS	0.80 (<0.001)	NS	NS	-0.68 (0.001)
Equine Calcaneus	0.29 (0.033)	0.32 (0.018)	NS	NS	-0.86 (<0.001)
Compression	NS	NS	NS	NS	-0.85 (<0.001)
Tension	NS	NS	NS	NS	-0.62 (0.014)
Neutral Axis	NS	0.52 (0.019)	NS	NS	-0.90 (<0.001)
Equine Radius	0.40 (<0.001)	0.86 (<0.001)	-0.38 (<0.001)	0.37 (<0.001)	-0.74 (<0.001)
Compression	NS	0.74 (<0.001)	NS	NS	-0.85 (<0.001)
Tension	NS	NS	NS	NS	NS
Neutral Axis	NS	0.91 (<0.001)	NS	NS	-0.79 (<0.001)
Sheep Radius	NS	0.79 (<0.001)	NS	NS	-0.79 (<0.001)
Compression	0.67 (0.033)	0.93 (<0.001)	NS	NS	-0.68 (0.029)
Tension	NS	NS	NS	NS	-0.65 (0.040)
Neutral Axis	NS	0.70 (<0.001)	NS	NS	-0.88 (<0.001)
Equine MC3	0.47 (<0.001)	0.90 (<0.001)	-0.43 (<0.001)	0.44 (<0.001)	-0.91 (<0.001)
Compression	0.75 (<0.001)	0.94 (<0.001)	-0.70 (<0.001)	0.76 (<0.001)	-0.97 (<0.001)
Tension	0.82 (<0.001)	0.94 (<0.001)	-0.67 (0.003)	0.77 (<0.001)	-0.83 (<0.001)
Neutral Axis	NS	0.87 (<0.001)	NS	NS	-0.89 (<0.001)
Sheep Tibia	NS	0.92 (<0.001)	NS	NS	-0.84 (<0.001)
Compression	NS	0.64 (0.045)	NS	NS	-0.83 (0.003)
Tension	NS	0.97 (0.007)	NS	NS	NS
Neutral Axis	NS	0.93 (<0.001)	NS	NS	-0.79 (0.019)
Chimpanzee Femur	NS	0.30 (<0.001)	NS	0.24 (0.007)	-0.80 (<0.001)
Compression	NS	0.52 (0.039)	NS	NS	-0.72 (0.002)
Tension	NS	NS	NS	0.52 (0.041)	-0.81 (<0.001)
Neutral Axis	NS	0.47 (0.006)	NS	NS	-0.82 (<0.001)
Human Femur	0.15 (0.045)	___	NS	___	-0.84 (<0.001)
Compression	NS	___	NS	___	-0.90 (<0.001)
Tension	NS	___	NS	___	-0.85 (<0.001)
Neutral Axis	NS	___	NS	___	-0.82 (<0.001)

All values shown are significant at $p < 0.05$. NS = not significant. Grayed cells are correlations where the r-value was 0.7 or greater. Note, the data in the same row as the species and bone name is for all osteons in that catergory.

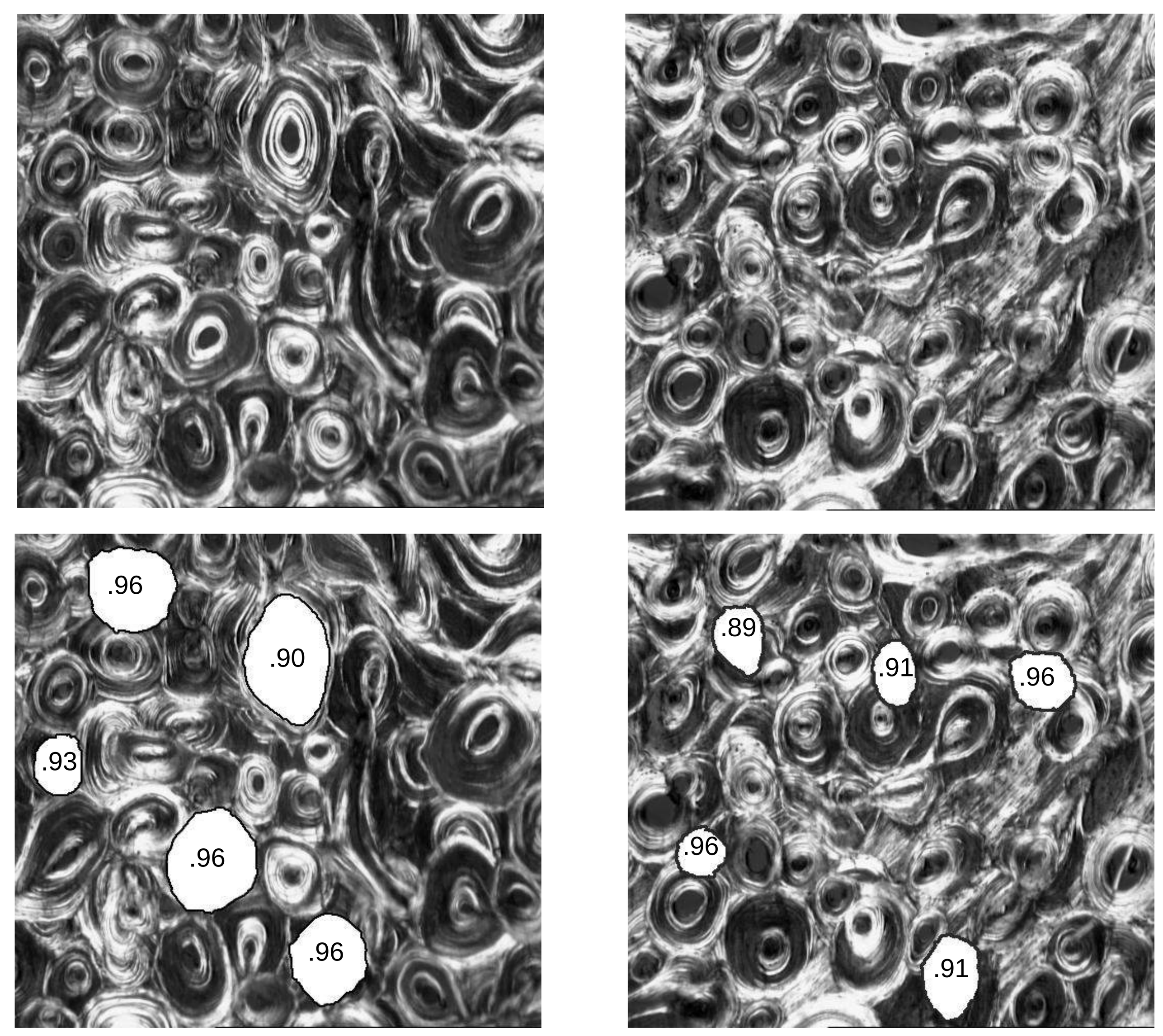
Discussion

The data clearly show that On.Cr is <u>not</u> helpful (because of the high inconsistencies) in determining: (1) strain mode distributions in more simply loaded bones, (2) load complexity categories, and (3) species affiliations.

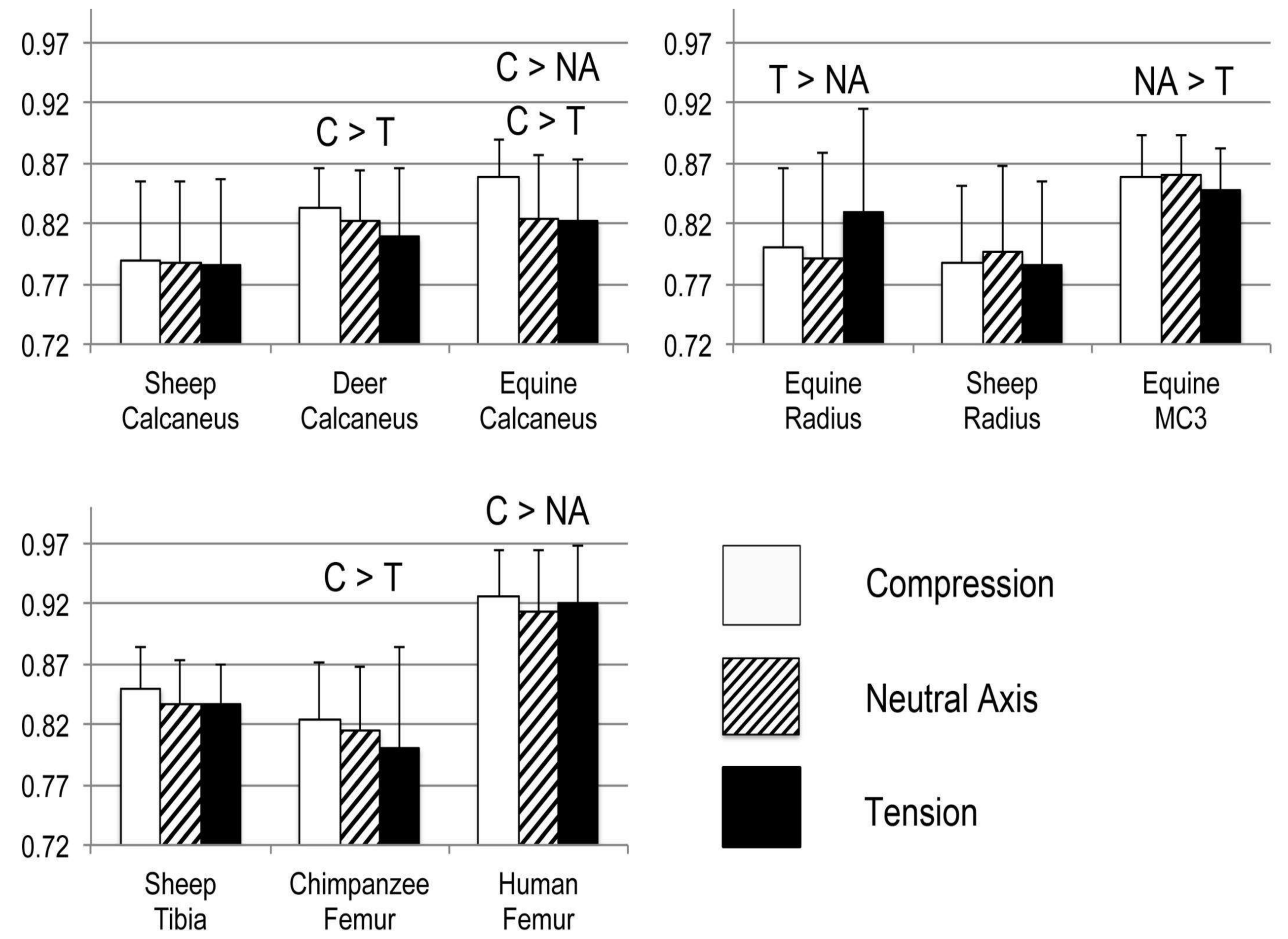
However, in some cases On.Cr has been shown to be useful in distinguish species (e.g., Dominguez and Crowder 20102 AJPA). But in these cases is it possible that the results are influenced by load history? Further studies are warranted to evaluate this possibility in more specific anthropological contexts *within the same species*. For example, the possible confounding influence of load history should be considered when comparing these human bone 'types': ribs (load complexity likely simple), humerus and tibia (likely intermediate), and femur (likely intermediate in proximal shaft vs. high complexity in mid-shaft).

Examples of CPL Images (Human Femur)

Lateral Cortex | Antero-Medial Cortex



ANOVAs For Strain-Mode Analysis



NA = Neutral Axis

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