Current Exclusion Criteria for Selecting Osteons for Circularity Analysis Are Potentially Problematic

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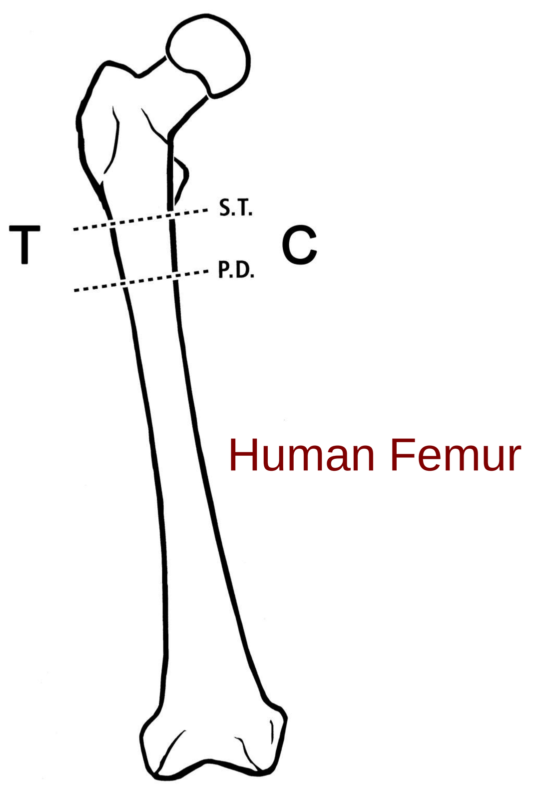
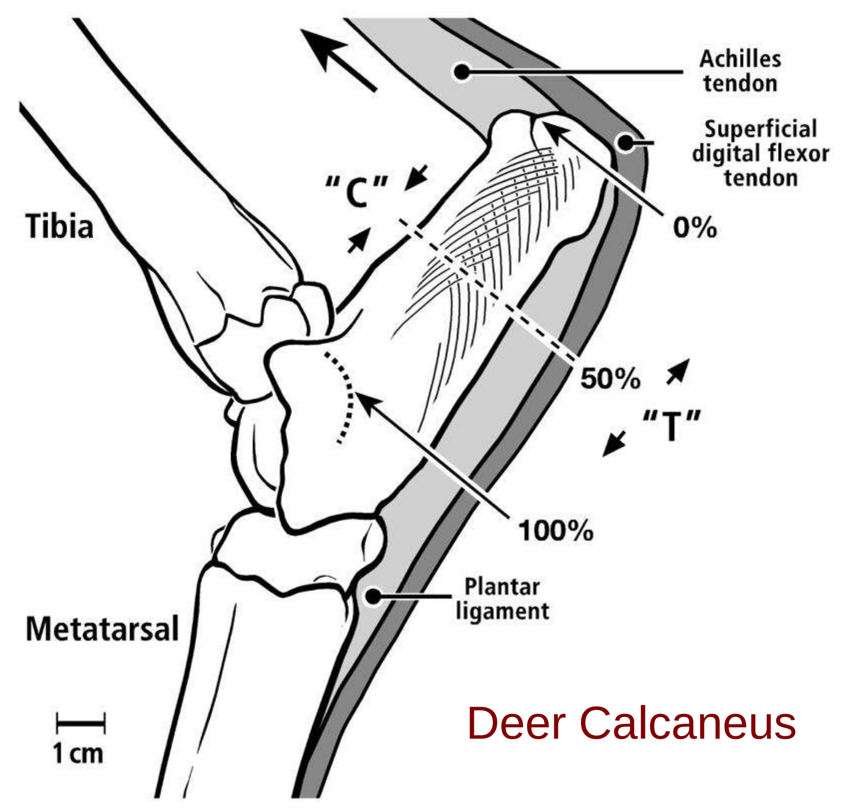
Introduction

Variations in secondary osteon (SO) cross-sectional shapes are useful for determining species affiliations and interpreting load history. SO cross-sectional shape is expressed as a “circularity index” [CI = 4π(area/perimeter^2); 1.0=perfect circle]. Recent studies recommend that SOs used in CI analyses should be selected based on central canal shape: (1)Crescimanno and Stout (“C&S” 2012, J. Forensic Anthro.) selected osteons with central canals >0.9 CI; (2)Dominguez and Crowder (“D&C” 2012, AJPA) selected osteons with central canals not exceeding 2:1 ratio of the max:min diameter. We hypothesized that the selection biases of these exclusion criteria eliminate important biological information.

Examples of Analyzed Locations





C = Compression, T = Tension

Methods

Using ImageJ we examined backscattered electron images (BSEi; ~2 micron/depth) and circularly polarized light images (CPLi; 100 micron/depth) from modern human femoral shafts (n=12, avg. 53years;25-71;male:female=3:9) and adult deer calcanei (representing a broad range of osteon sizes/shapes): (1) humans: 400 osteons/BSEi, 1784 osteons/CPL; (2) deer: 1328 osteons/BSEi; 177 osteons/CPL).

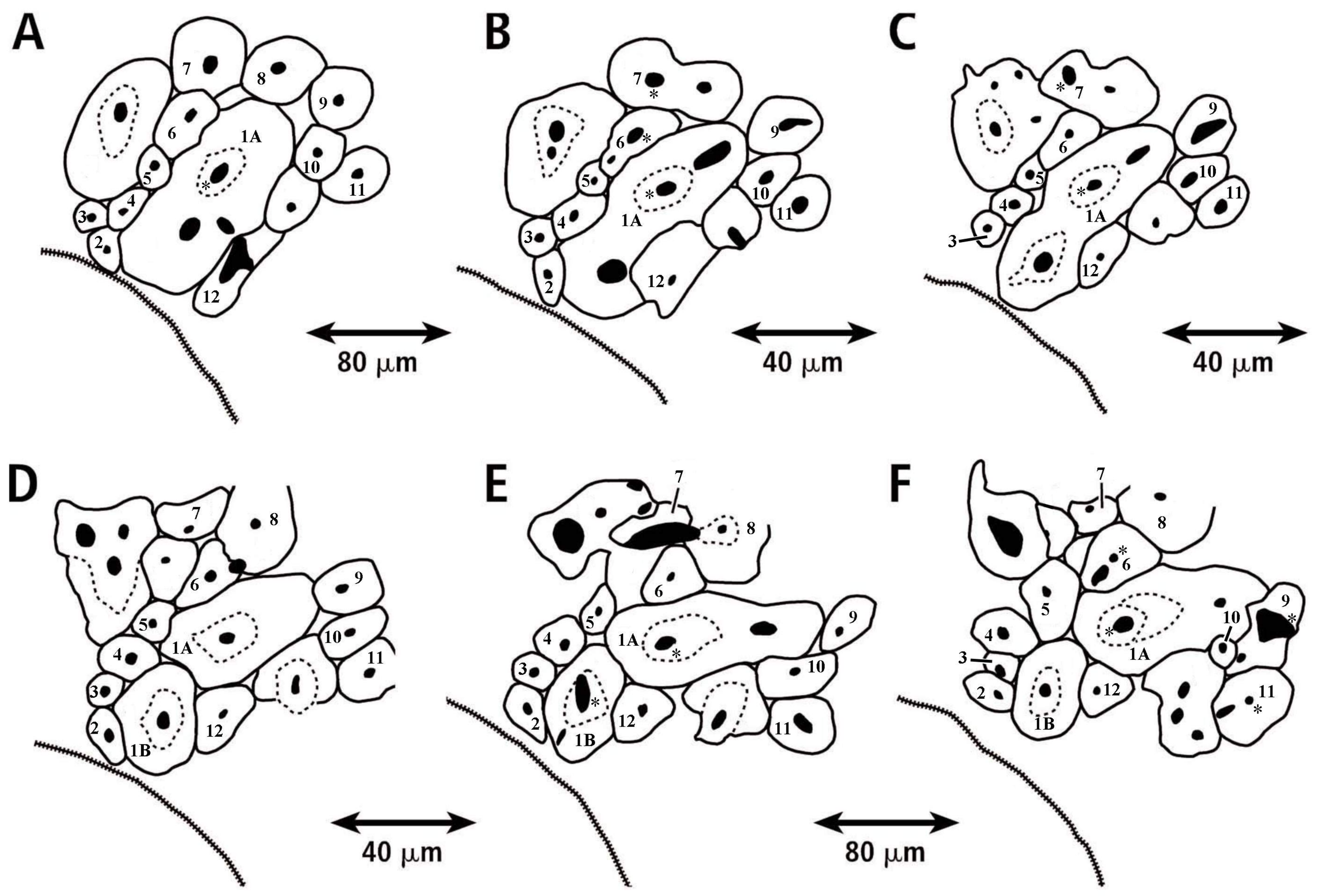
Statistical analyses (one-way ANOVAs) were conducted with samples using (1) all osteons, and (2) the remaining osteons after excluding those based on the C&S and D&C criteria (see 1st paragraph above).

For illustrative purposes, an additional analysis was conducted on “tension cortex” osteons from serial sections of a deer calcaneus (See “T” in figure above) (Skedros et al., 2007).

Results

C&S criteria excluded: (1) deer 307(23%) osteons from BSEi, and 125(70%) osteons from CPLi; (2) human 80(20%) osteons from BSEi, and 680(38%) osteons from CPLi. D&C criteria excluded: (1) deer 116(9%) osteons from BSEi, and 79(45%) osteons from CPLi; and (2) human 45(11%) osteons from BSEi, and 232(13%) osteons from CPLi.

Although both the C&S and D&C exclusion criteria reduced sample sizes, statistical analyses were still possible. However, the significant CI difference between dorsal “compression” and plantar “tension” cortices of the deer calcaneus shown when using all SO became non-significant using the samples remaining after the exclusions. **Therefore, these exclusion criteria forced an errant interpretation of load history.**

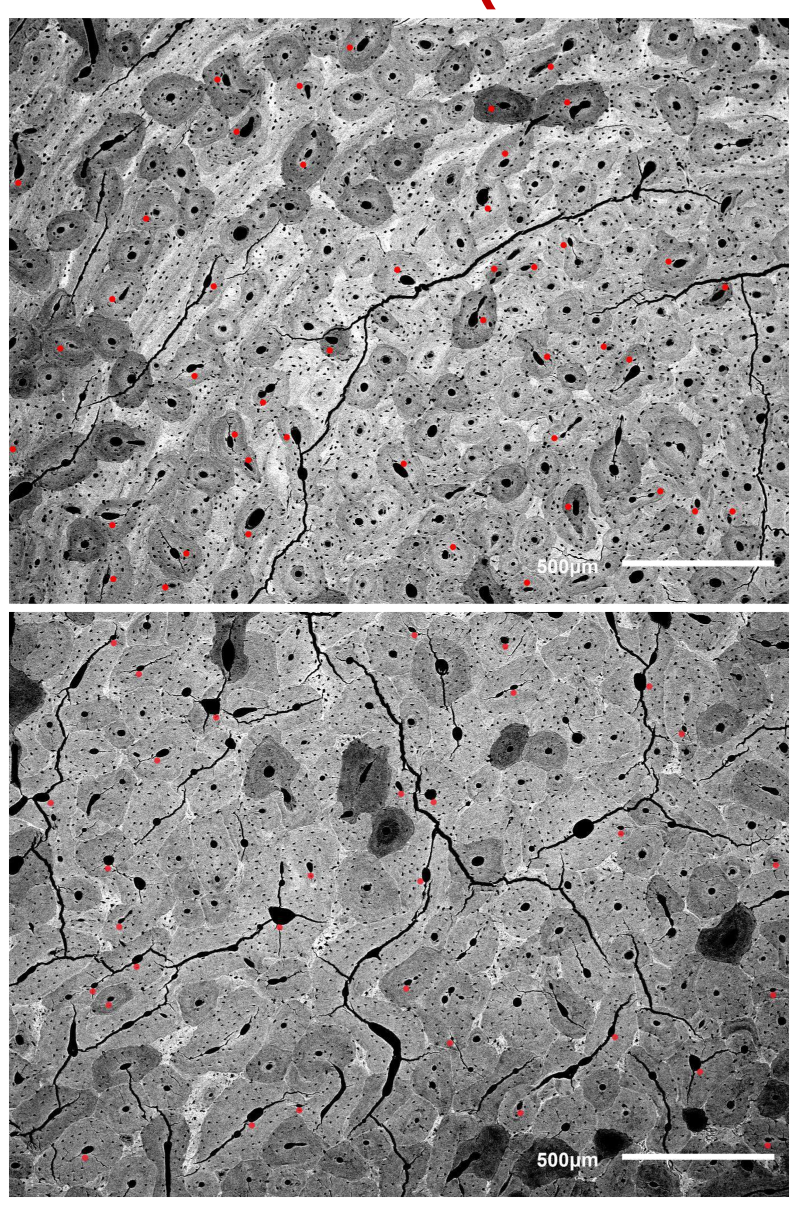


Outline drawings of osteons from a serially sectioned plantar “tension” cortex of a mule deer calcaneus (“T” in drawing at left). The reduced CI (i.e., irregular osteon shapes) is thought to be mechanically adaptive (Skedros et al., 2007). The data for these osteons are in the table.

Examples of Exclusions (Deer Calcaneus)*

Dorsal

Plantar



*Red dots = osteons excluded by CI < 0.9

Measurements From the Serially Sectioned Osteons (at left)

		A	B	C	D	E	F
1A	On.Cr	0.73	0.54	0.60	0.78	0.65	0.68
	On.El	2.11	2.46	2.60	1.83	2.53	2.08
	Cn.Cr	0.85	0.94	0.79	0.91	0.85	0.90
	Cn.El	1.45	1.31	1.25	1.58	1.72	1.32
1B	On.Cr	merged w 1A	merged w 1A	merged w 1A	0.90	0.84	0.88
	On. El				1.36	1.67	1.60
	Cn.Cr				0.91	0.74	0.94
	Cn. El				1.42	2.38	1.11
2	On.Cr	0.85	0.81	Not Seen	0.80	0.78	0.88
	On.El	1.53	1.86		1.81	1.72	1.62
	Cn.Cr	0.85	0.86	Not Seen	0.93	0.89	0.78
	Cn.El	1.43	1.54		1.36	1.54	1.43
3	On.Cr	0.94	0.95	0.97	0.94	0.93	0.86
	On.El	1.15	1.19	1.13	1.31	1.32	1.40
	Cn.Cr	0.91	0.89	0.94	0.94	0.95	Not Seen
	Cn.El	1.25	1.33	1.32	1.39	1.34	
4	On.Cr	0.73	0.82	0.90	0.90	0.94	0.91
	On.El	1.84	1.77	1.20	1.39	1.14	1.54
	Cn.Cr	0.82	0.91	0.83	0.92	0.88	0.93
	Cn.El	1.37	1.40	1.60	1.28	1.39	1.25
5	On.Cr	0.93	0.88	0.85	0.86	0.80	0.86
	On.El	1.47	1.22	1.30	1.33	1.82	1.50
	Cn.Cr	0.94	0.89	0.93	0.89	0.86	0.90
	Cn.El	1.27	1.43	1.09	1.29	1.41	1.46
6	On.Cr	0.84	0.65	0.74	0.65	0.85	0.87
	On.El	1.65	2.23	1.93	1.76	1.27	1.47
	Cn.Cr	0.90	0.84	0.82	0.94	0.90	0.96
	Cn.El	1.41	1.49	1.29	1.27	1.55	1.29
		A	B	C	D	E	F
7	On.Cr	0.92	0.72	0.73	0.74	0.38	0.82
	On.El	1.17	1.93	1.64	1.88	3.11	1.49
	Cn.Cr	0.94	0.93	0.92	0.84	Not Seen	0.93
	Cn.El	1.33	1.51	1.31	1.67		1.41
8	On.Cr	0.94	merged w 7	merged w 7	Open	Open	Open
	On.El	1.32					
	Cn.Cr	0.93	0.88	0.82	0.93	0.88	0.87
	Cn.El	1.40	1.51	1.67	1.27	1.46	1.54
9	On.Cr	0.97	0.93	0.94	0.94	0.80	0.64
	On.El	1.13	1.38	1.29	1.35	1.92	2.19
	Cn.Cr	0.95	0.56	0.66	0.86	0.82	0.84
	Cn.El	1.22	2.90	2.64	1.59	1.54	1.33
10	On.Cr	0.95	0.85	0.87	0.80	0.76	0.95
	On.El	1.23	1.58	1.47	1.92	2.04	1.25
	Cn.Cr	0.92	0.84	0.80	0.79	0.91	0.96
	Cn.El	1.26	1.53	1.97	1.74	1.67	1.20
11	On.Cr	0.87	0.95	0.90	Open	0.92	0.92
	On.El	1.56	1.31	1.60		1.30	1.37
	Cn.Cr	0.93	0.95	0.88	0.94	0.82	0.93
	Cn.El	1.36	1.19	1.30	1.09	1.80	1.23
12	On.Cr	0.57	0.77	0.76	0.83	0.88	0.89
	On.El	3.17	1.63	2.14	1.60	1.35	1.16
	Cn.Cr	0.65	0.88	0.90	0.86	0.92	0.96
	Cn.El	1.79	1.60	1.15	1.78	1.36	1.28

When osteons containing more than one canal, the canal measurement that is listed is marked on the figure with an asterisk(*).
Dominguez and Crowder (D&C) Cn.El ≥2 excluded (Shaded).
Crescimano and Stout (C&S) Cn.Cr. <0.90 excluded (Shaded).
There were no osteon canals with a Cn.El ≥2 with a Cn.Cr. >0.90. If it was excluded by D&C criteria it was also excluded by C&S criteria.
The reverse however is not true. There are several Cn.Cr. <0.90 with a Cn.El <2. Several osteons excluded by C&S criteria would not have been excluded by D&C criteria.

Discussion

We recommend that all osteon data be reported so that important biological data are not missed. Furthermore, if it is concluded that some osteon variants should be excluded, then we recommend that their % prevalence is reported.

References

(1) Crescimanno, A., and Stout, S. D. (2012) J Forensic Sci, 57: 287-294,
(2) Dominguez, V. M., and Crowder, C. M. (2012) Am J Phys Anthropol, Suppl. 54: 84-91,
(3) Skedros et al. (2007) Cells Tissues Organs, 185:285-307

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