

Sealed Osteons: A Pathological Consequence or Natural Circumstance of Extensive Remodeling?

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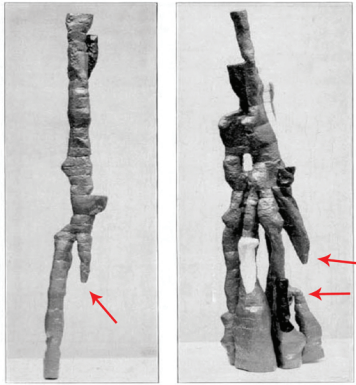
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Introduction

Sealed osteons (SeO) are unusual secondary osteon (Haversian system) variants. They are defined as the continuation of osteonal infilling resulting in complete obliteration of the Haversian canal (canal fully sealed with bone) (Congiu and Pazzaglia ("C&P"), 2011 Anatomical Record). SeO do not represent micropetrosis (central canal "plugging") or osteocyte lacuna plugging with hypermineralized tissue related to aging; SeO are "sealed" with apparently normal bone. SeO are rarely studied; C&P reported 4-5% SeOs of all secondary osteons from three tibiae (post-traumatic amputations; ages 25, 28, 52; all males). They suggest that SeO are the natural/physiological consequence of ischemia that sporadically occurs during remodeling (i.e., some osteons seal because their blood supply is diminished or cutoff during formation of nearby/adjacent osteons).

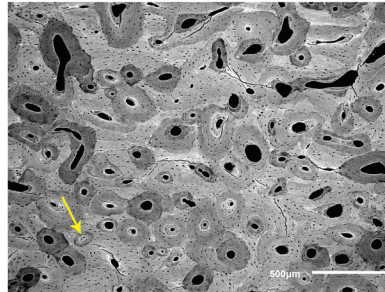
We hypothesized a similar prevalence of SeO would be found in various non-primate, highly remodeled bones (deer, sheep and horse calcanei; sheep and horse radii, sheep tibiae; horse third metacarpals) and from modern human femora where an aging effect might be detected (35-71 years; n=10,male:female=8:2). Hundreds of backscattered (BSE) images from our previous studies were examined.

Three-Dimensional Secondary Osteon Reconstructions

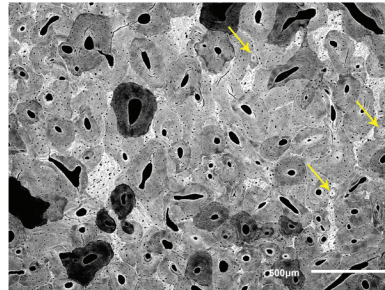


Photographs of three-dimensional reconstructions of secondary osteons from a dog femur at the mid-third diaphysis. They demonstrate the complexities of branching of 'single' osteons as they course through the bone. The arrows show "closing cones" (do SeO occur in these locations?). [From Cohen and Harris; British JBJS, 1958]

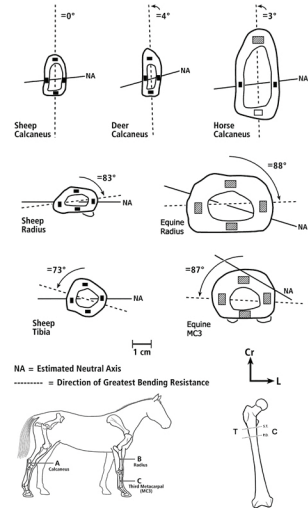
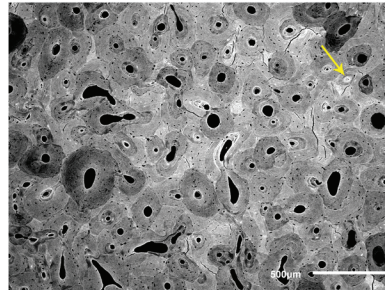
Human Femur BSE Images (Arrows Show Sealed Osteons) Anterior Cortex



Posterior Cortex



Lateral Cortex



Results and Discussion

Sealed osteons occurred in <0.1% secondary osteons in non-primate bones even in extensively remodeled regions (i.e., much greater %osteonal bone than humans) and ~1% in human femora, but without an age-related increase.

The 4-5 fold higher prevalence of SeO identified by C&P might reflect ischemia preceding and/or caused by the trauma/amputation in the three tibiae that they examined. If correct, then an increased prevalence of these unusual osteon variants should be viewed as a pathological consequence, not the outcome of ischemia caused by natural extensive osteonal remodeling. Perhaps they represent sealing of the 'closing cone' of some secondary osteons (see arrows in 3D osteons at far left). Support for this idea includes the much lower prevalence of SeO (2.2%) reported in healthy modern male tibiae and femora in a follow-up study by Pazzaglia et al. (2013). However, it is still not clear why this prevalence is several orders of magnitude lower in the non-primate bones that we studied.

References

Congiu, T., and Pazzaglia, U. E.: (2011) The sealed osteons of cortical diaphyseal bone. Early observations revisited with scanning electron microscopy. The Anatomical Record, 249:193-198.
Pazzaglia et al.: (2013) Morphometric analysis of osteonal architecture in bones from healthy young human male subjects using scanning electron microscopy. J. Anat. 223:242-254



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