

REGIONAL DENSITY AND MORPHOLOGY OF EQUINE HOOF WALL TUBULES

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Purpose: This study was conducted to answer the following questions:

- What is the quantitative tubule density of equine hoof wall across the dorsal to palmar plane (a cross-sectional plane of full thickness hoof wall)?
- Does it change in the proximal-distal plane?
- Is there pattern variation around the perimeter of the foot?
- Does the tubule density follow a similar pattern to previously documented laminar density patterns?
- Is there variation between different groups of horses?

Methods: The study included 12 horses: 4 racing Quarter Horses, 3 feral horses, 5 pleasure horses. Race and feral horses were age-matched and cadaver feet were used. Samples from pleasure horses were obtained from live feet during routine farrier trimming. Samples were taken from the bearing surface of hoof wall from live horses and from several different levels in the cadaver feet. Samples were collected from one front foot of each horse at the toe, medial quarter and lateral quarter. Hoof horn samples were processed for histological analysis.

Findings: This study confirmed previous findings of a zonal radial decrease in tubule density across the cross-section of hoof wall at the toe from outer wall to the dermal edge of the laminar junction. We documented two novel findings: tubule density varies in the proximodistal plane, and tubule density varies around the perimeter of the hoof.

Microscopic analysis of slides from all feet sampled showed a radial pattern of increased tubule density across the axial to abaxial plane (this means from the inner to outer edge of the hoof wall). All feet had higher tubule density in the toe than in the lateral quarter. Density in the quarters varied within each foot. The quarter with higher tubule density was on the medial side of the foot, which was the more upright wall in all but one of the feet sampled. Feral feet showed an overall lower density at the toe wall compared to domestic feet, except for the outermost zone where feral feet had a higher tubule density than domestic feet.

Proximodistal density calculations were measured from serial sections in 5 sites at the toe collected from 3 feet (one feral and two racehorse samples). Density was higher in the more proximal section at the dermal edge. The distal section had higher density in the zones closest to the outer hoof wall.

Morphological differences were noted between tubules in different zones. Near the dermal edge, horn tubules closest to the laminae are oriented in line with the dermal tips and appear to be “budding off” from secondary epidermal laminae between two neighboring primary epidermal bases. Approximately 2 millimeters outward from the dermal edge there is a zone approximately 2 millimeters wide where the tubules are the largest with the most well defined cortical zone and largest medullary cavities. Continuing toward the outer hoof wall from this zone, the tubule cortices become less well-defined and tubule density rises progressively. The outermost zone of hoof wall, the periople, had tubules similar in size and density to the rest of the outer hoof wall, but consistently showed uptake of stain similar to that of the inner hoof wall.

Comments:

Previous research on hoof wall has documented biochemical differences, hydration gradients, mechanical differences and ultrastructural distinctions (seen under an electron microscope) across different zones of hoof wall.

Major findings of this study reveal new information about hoof wall tubule density. Hoof wall tubule density patterns are similar to laminar density patterns from toe to lateral quarter but different between toe and medial quarter. There is variation among different groups of horses. It is possible that different hoof wall loading patterns could account for the difference in tubule density. Hoof horn tubules may respond differently than the laminae do to similar loads. It is also possible that tubular horn responds in a similar fashion to the laminae, but that loads on the tubular horn are different than the loads occurring in the laminar junction.

Clinical relevance: It is not known if variation between groups is due to breed, age, sex, occupation, hoof balance, or shoeing. The feral and racehorse group were age-matched, but no other variables were similar. The pleasure horse group showed the largest data ranges, which is to be expected if tubule density is affected by multiple factors. Pleasure horses used in this study comprised a range of ages, breeds, occupational histories, and environmental conditions.

To answer the question of what precisely is changing in the hoof wall horn when the foot adapts, we need data collected over time from a sample group of live horses exposed to changing environmental conditions. The present study has established that tubule density can be studied from sample hoof clippings removed during routine hoof care. Future research may identify markers of hoof wall thickness, tubule density and tubule morphology as diagnostic and prognostic indicators for important equine foot conditions.

Future questions include:

- How variable is this tubule pattern? Are horses born with a full set of tubules?
- Does tubule density change over time or is the adaptation when horses are moved from hard to soft ground etc. primarily some other aspect of hoof wall changes?
- What is the relationship between inner and outer edge tubule quality and alignment?