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Sole and Pedal Bone Shape

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We shall refer to the entire sole of the hoof capsule as the 'sole body'. This article will focus on the most common deformities affecting the shape of the sole body. Like everything else on our planet, gravity also has an effect on the sole. Loading forces placed upon the sole can change its shape to varying degrees. A sole can be crushed in certain areas, pushed down past the walls, can have different vertical depth (sole thickness) or display any combination of the above.

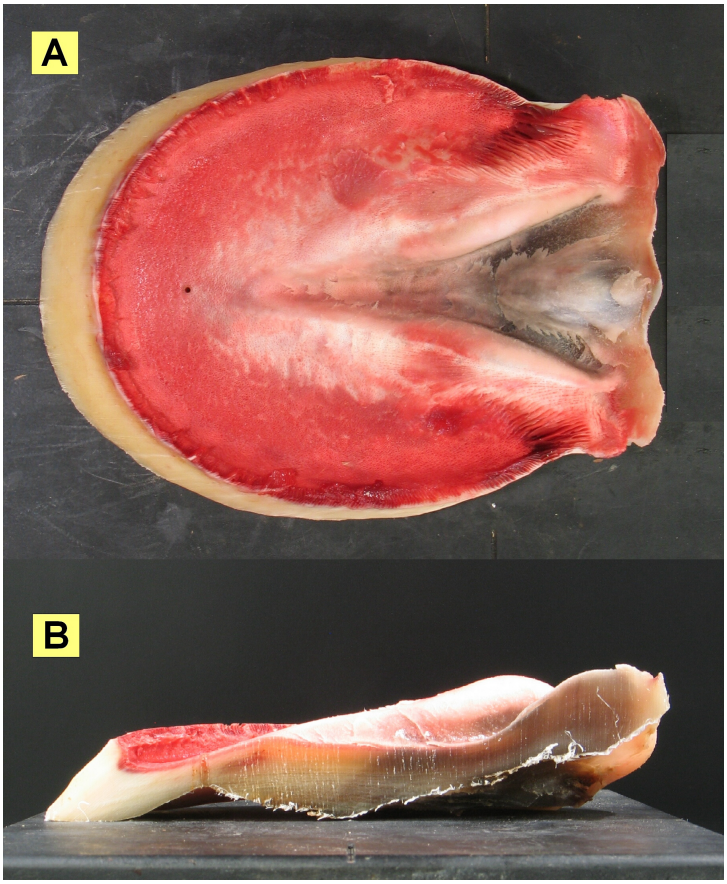

Figure 1. Top view of the sole in A, and a cross-section in B. A small hole was drilled at the tip of the frog prior to dissection.

There are obviously other contributing factors to a deformed sole such as aging, genetics, specific conformation and biomechanical attributes of the horse. Riding, trimming and shoeing methods along with environmental factors have also a significant impact on the shape of the sole.
We must point out that it is not uncommon for a horse to have some sole body deformities. For instance, the leading edge of the sole often shows signs of 'sagging' even in reasonably good hooves (see figure 1.) The caudal part of the sole body is one of the areas that often experiences serious deformities. The bars and the arches that make up this area can be crushed down somewhat. This deformation of the arch of the sole can cause a change in the angle of the pedal bone relative to ground. In severe cases, when the back portion of the arch crushes down, the pedal bone's orientation can be such that we say that it has a negative palmar angle (see figure 2). This is not to say that all negative palmar angles are caused by crushed arches.

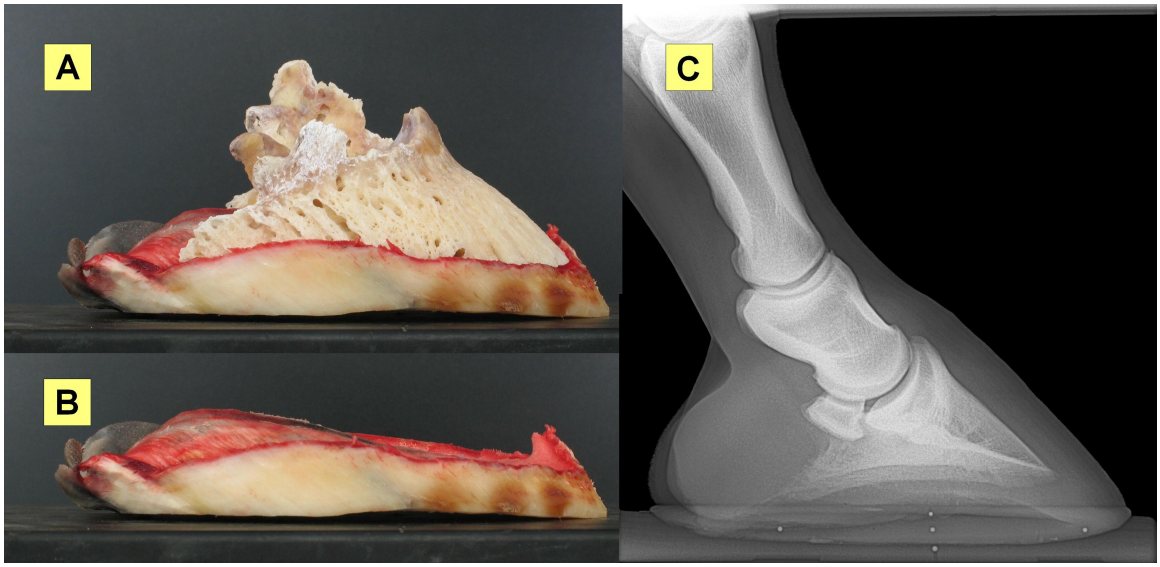

Figure 2. Sole sunk in the caudal (back) area. The radiograph in C - is that of a live horse with similar sole and pedal bone conformation to that of A, B.

An area that often displays deformities is the toe area of the sole. This area will be dropped to varying degrees and may have a dependence on the arch height. The position of the pedal bone will also adjust to this height. A higher arch height generally translates into a larger palmar angle. A numerically large palmar angle will shift the load at the pedal to the tip of the pedal bone thus creating stress at the toe part of the bone and the portion of the sole underlying it.

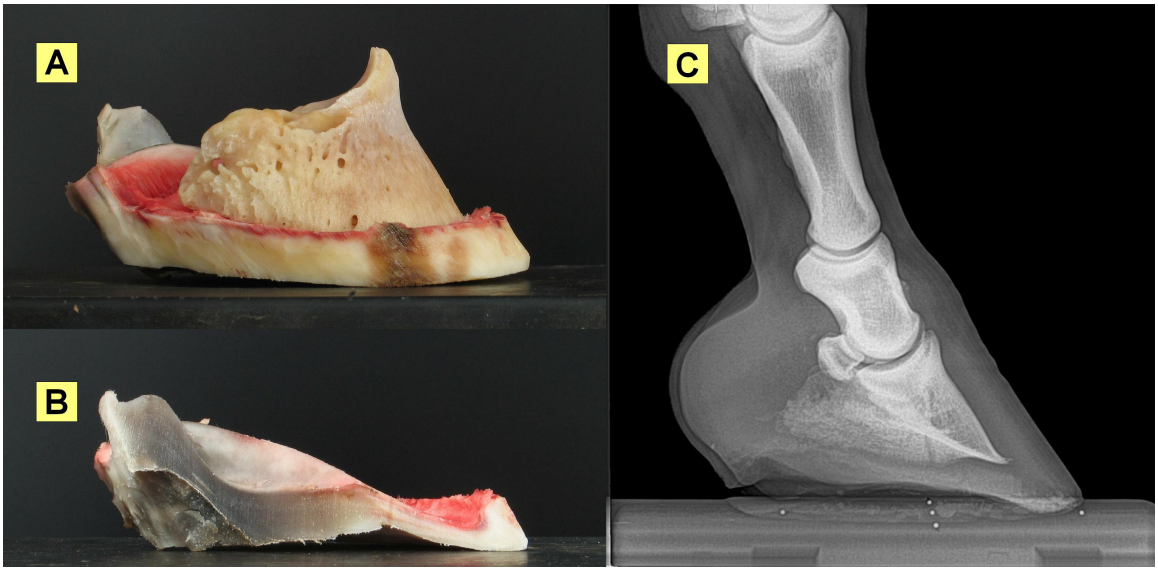

Figure 3. High arch with sunk anterior (front) part of the sole. The radiograph in C is that of a live horse with similar conformation to the sole and pedal bone of A, B.

The entire sole body can be crushed. This kind of deformity can often be noticed in flat footed hooves, see figure 4.

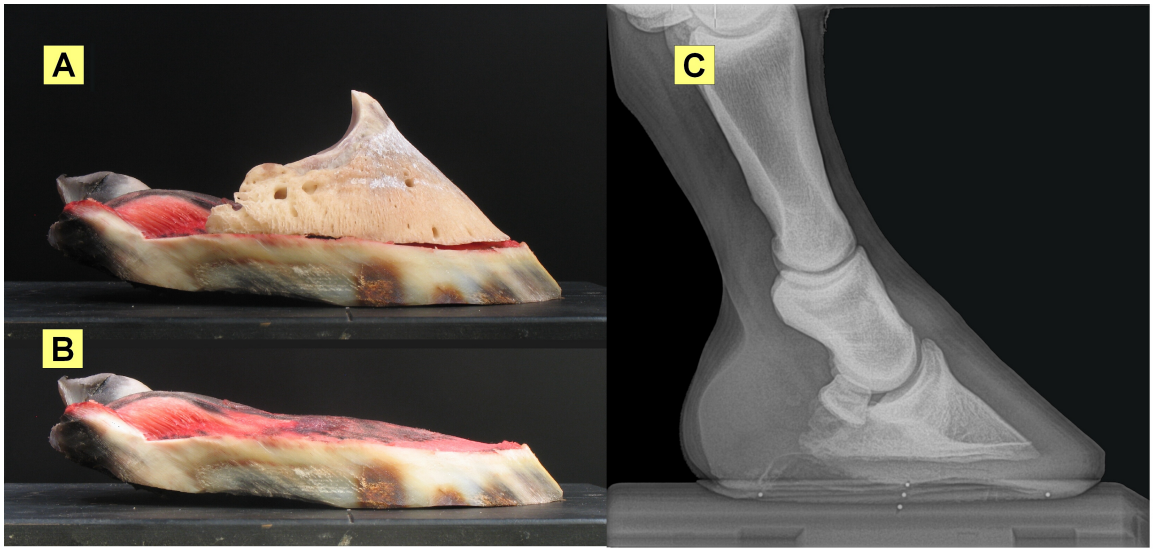

Figure 4. Flat sole. The radiograph in C is that of a live horse with similar conformation to the sole and pedal bone of A, B.

Sole deformities have far reaching consequences. There is a one to one relationship between the shape of the sole body and the shape of the pedal

bone. Loading forces along with other factors will not only affect the shape of sole but also that of the pedal bone.

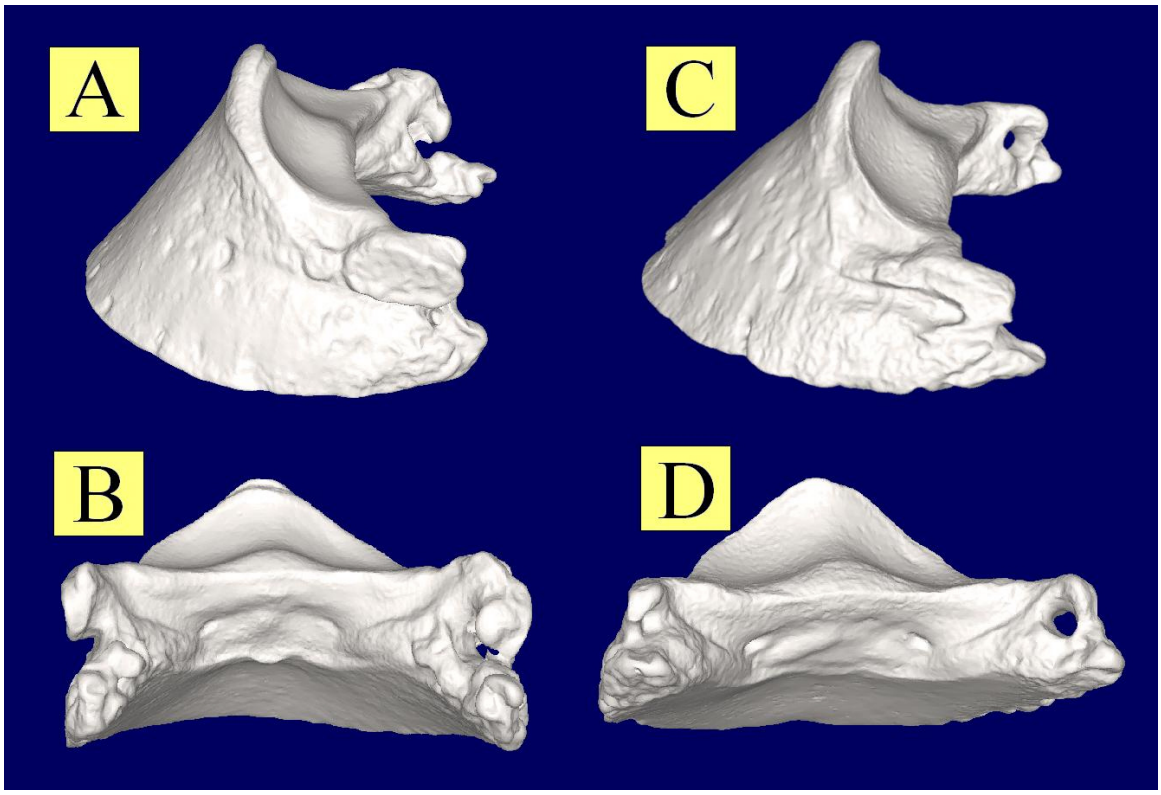

Figure 5. These scanned bones are an example of different bone morphologies. Bone morphologies are for the most part the result of load and external causes. Images A & B are the same bone and one that has a large solar curvature; images C & D are a second bone which has a much flatter solar surface.

It is generally accepted that a foal starts with a very compact pedal bone and a good sole body. As the foal matures, the bone and sole will change significantly --- an unavoidable part of the process of growing up. The shape of the bone and sole in a young horse is as much the result of developmental issues (i.e. growth spurts, temporary mechanical compensation and innate conformation of a particular foal) as external factors (hoof maintenance, weather, type of soil and level of free exercise, etc.)

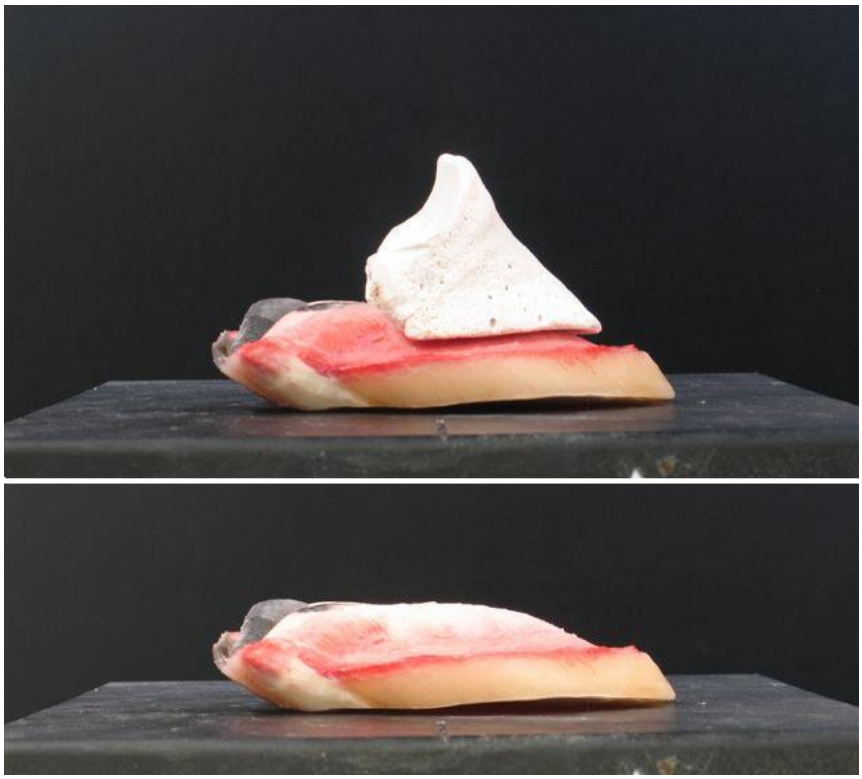

Figure 6: The pedal bone and sole of a three month old foal shows a nice high sole arch, and the pedal bone has correspondingly a good arch.

Changes in the shape of pedal bone and sole will eventually affect the joint alignment of the entire limb and ultimately the whole skeletal structure, see figure 7. In turn, this may cause the horse to alter its 'natural' range of motion. Eventually, this chain of events may lead to lameness issues further up in the leg or other part of the body, not necessarily at the hoof. Remember that horses are masters at gait compensation.

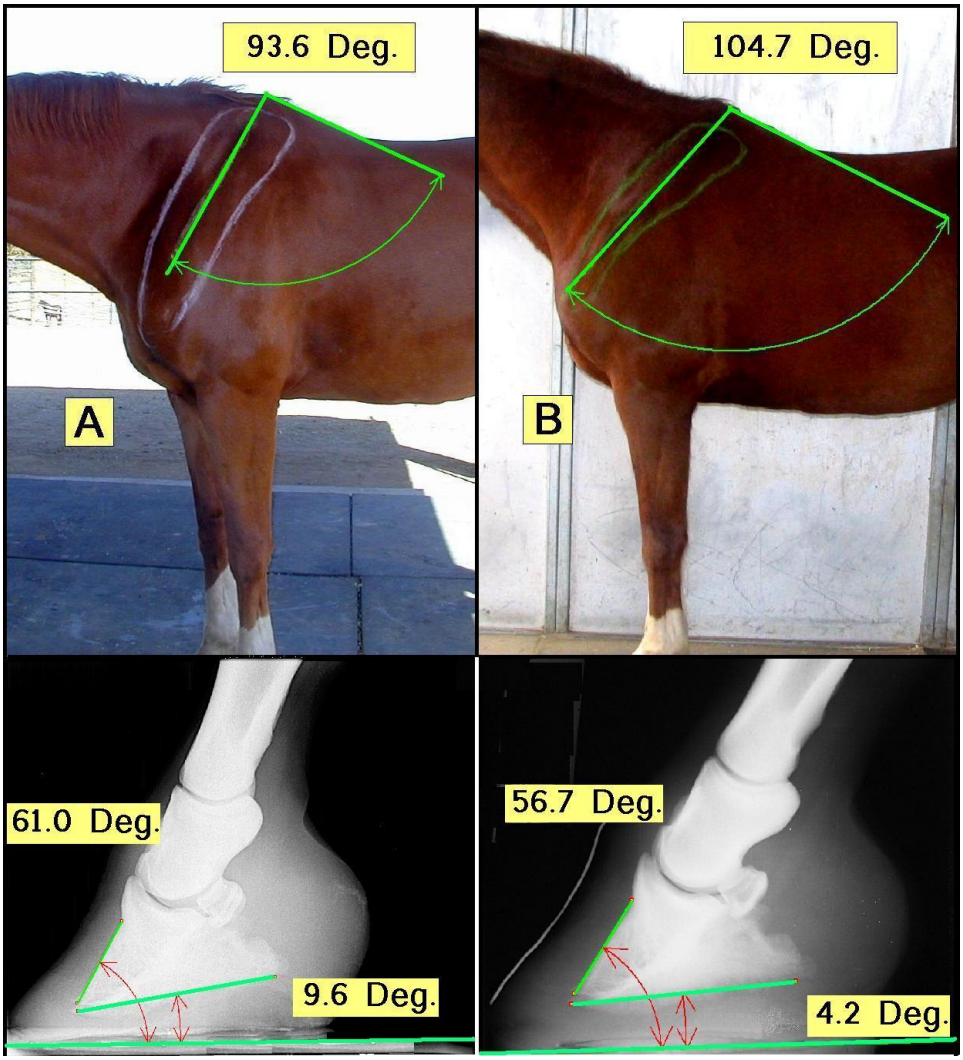

Figure 7. These shoulder pictures are not taken under exactly the same conditions – horses cooperate only so far! One can notice the difference in shoulder angles. Even accounting for some photographic error, a change is apparent, and the relationship of that change to angulation of the pedal bone is shown here. The palmar angle was reduced from 9.6 degrees to 4.2 degrees over a few months by trimming the heel lower.

There has been much discussion in the literature concerning the appropriate value for the palmar angle of the pedal bone. First of all, there are some challenges in measuring this angle – in figure 2 the curving palmar aspect of the bone makes it difficult to set a reference. The orientation of the pedal bone, as measured by the palmar angle, depends on the shape of the sole body (as depicted in figures 2 – 4) and also on how the hoof is trimmed (figure 7). It is important to note that for any given horse the shape of its

sole places a constraint on the possible palmar angle that might be achieved by means of trimming. Hence, we believe it is not possible to declare that a certain palmar angle is ideal for all horses, at best we could give a range of values. However, for a given individual horse, it may be possible to say what is the best angulation.

To understand the exact ramifications of hoof conformation as it relates to the horse, we need more information on equine locomotion (energetics, kinematics and dynamics), the mechanics of biomaterials and equine neurology. When compared to human biomechanical research, equine research is in its infancy. This is not necessarily the result of lack of brain power but lack of funding. Also, it is an industry that is not necessarily ready to face the truth concerning how our uses of horses affect their well-being. Generally speaking, the study of biomechanics is a relatively new field compared to that of the well-established fields of biology and physiology. There is still much to be gained by future explorations of equine biomechanics.