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A case-control study of bone density patterns in the metacarpophalangeal joint between non-racehorses and thoroughbred racehorses with and without fractures of the metacarpophalangeal joint

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Prefatory note

During the Master of Equine Veterinary Science at Utrecht University students fulfill a research project. This research project brings the opportunity for students to study abroad. This paper is a final report of the research project which was supervised by dr. C. Kawcak and MSc. B. Nelson of the Veterinary Teaching Hospital at Colorado State University, United States of America.

Content

Summary

Reason for performing study

The metacarpophalangeal joint carries high loads and is one of the most common sites of overload arthroses and joint failure. Racing seems to be a risk factor for fractures and fractures occur mostly on the forelimbs.

Objective

The objective of this study was to utilize computed tomography from clinical cases to establish subchondral bone density patterns of the articular surface in limbs with third metacarpal condylar fractures, proximal phalanx fractures and proximal sesamoid bone fractures and to look at the differences and agreements with non-fractured limbs and between non-racehorses and racehorses.

Material and methods

An experimental group of clinical CT scans of 22 forelimbs of thoroughbred racehorses with fractures in the third metacarpal, proximal phalanx or proximal sesamoid bones was compared to a control group of 24 non-fractured limbs of Quarter horses. Also, 18 racehorses from the fractured group were used as controls for other bones than their fractured bone. An image analysis program generated color-coded clinical-CT images and the different bones were analyzed at different denser or less dense areas of the bone. The Fisher's exact test was used to establish the statistical significance of differences.

Results

In this study, differences in subchondral bone density patterns of the third metacarpal, the proximal phalanx and the proximal sesamoid bones were found between the racehorses and non-racehorses. Significant differences in subchondral bone density patterns were found on the sagittal groove, in the middle and at the lateral and medial side of the third metacarpal bone, in the middle and at the lateroproximal side of the proximal phalanx and at the side where the proximal sesamoid bones are facing each other. Also, significant differences in subchondral bone density patterns were found between fractured and non-fractured limbs in the proximal phalanx and the proximal sesamoid bones. These differences were found in the middle of the proximal phalanx and the side where the proximal sesamoid bones are facing each other.

Conclusion and Clinical Relevance

There was a significant difference between the fractured and non-fractured limb and the non-racehorses and racehorses in this paper. However, due to the limitations of this study more research regarding this subject is still necessary.

Keywords: Equine, fractures, racing, bone density, third metacarpal, proximal phalanx, proximal sesamoid bones

Introduction

Musculoskeletal injury is the greatest reason for mortality in thoroughbred racehorses. Racing seems to be a risk factor for fractures, which occur mostly on the forelimbs. (1-3) The metacarpophalangeal joint carries high loads and is one of the most common sites of overload arthroses and joint failure.(4) In addition, apical fractures of the proximal sesamoid bone are very common and can occur simultaneously with fractures of adjacent bones, including fractures of the proximal, articular aspect of the proximal phalanx and fractures of the distopalmar aspect of the 3rd metacarpal bone, together also called “the big three”.(5)

Third metacarpal bone

The third metacarpal bone is one of the strongest elements of the skeleton (6) At the distal epiphyses, a sagittal ridge separates two condyles, whereby the condylar grooves are abaxial from the sagittal ridge.

Third metacarpal fractures

Condylar fractures are site-specific whereby the lateral condyle is involved more often than the medial condyle. They are usually occurring during high-speed exercise. (8) Different theories suggest that the fractures occur in adapted bone. (8,10)

Subchondral sclerosis occurs in the palmar aspect of both medial and lateral condyles of the third metacarpal bone. Articulation of the condyles with the proximal sesamoid bones, which confer the mechanical load and create stress over the condyles, could explain this. The sagittal ridge contacts the intersesamoidean ligament which transfers less stress onto the opposing surface, and therefore shows no signs of sclerosis.(10) A theory suggests that consequently, subchondral sclerosis occurs more often on the condyles of the third metacarpal bone across the distopalmar aspect than at the sagittal ridge, which is likely to be significantly stiffer. (2,10,11) The stiffening of the medial and lateral condyles will be partly responsible for developing cracking into the subchondral bone. A relative decrease in density at the parasagittal groove may predispose this site to fracture. (12) Continued overloading increases accumulation and coalescence of microcracks, which may result in the development of a fracture. (13) Another theory suggests that the trabecular infrastructure of the distal condyle of the third metacarpal bone is anisotropic, which can be the cause of the many fractures on this side.(14)

Proximal phalanx

The proximal phalanx is proximally wider than the distal articular phalanx of the metacarpal bone and has proximally an axial groove in which the sagittal ridge of the third metacarpal fits. The collateral ligament of the metacarpophalangeal joint enters the proximal phalanx at the tubercles of each side. On the distal end, there are two condyles separated by an axial groove which receive the collateral ligaments of the pastern joint. At the palmar surface, several ligaments are attached.

Proximal phalanx fractures

The proximal phalanx fractures occur mostly through the proximal sagittal groove along a sagittal plane. (15,16) Old theories of sagittal fractures of proximal phalanx suggest that the rotary movement between the sagittal ridge of the third metacarpal bone and the sagittal groove of the proximal phalanx induces forces that cause fractures. (17) A new interpretation is that the proximal phalanx has a deficient adaptive response to exercise which makes the proximal phalanx unable to deal with the compressive and torsional forces. This suggests that the fractures occur after a longer term of repetitive loading. (18,19)

Proximal sesamoid bones

The proximal sesamoid bones are located with their triangular shape at the distal palmar side of the metacarpophalangeal joint. The three-sided form faces on the dorsal side the condyle, on the palmar side the flexor tendons and on the abaxial side the thick branch of the interosseous ligament, which gives the abaxial side a concave shape. The function of the proximal sesamoid bones is to redistribute the load on the metacarpophalangeal joint over the proximal phalanx and sesamoid bones, instead of the proximal phalanx only. The proximal sesamoid bones slide slightly during foot impact because of the elasticity of the suspensory apparatus and the flexor tendons.(6)

During the weight bearing phase of the movement the distal sesamoidean ligaments, that connect the proximal sesamoids to more distal structures, give resistance to metacarpophalangeal hyperextension. During this hyperextension, the proximal sesamoid bones slide below the condyle, where the palmar (intersesamoidean) ligament extends the bearing surface for the flexor tendons to give a frictionless movement of overlying flexor tendons. While the joint is totally flexed, the sesamoid bones lose contact with the condyle and slide upwards at the palmar side of the metacarpal bone.(6,20,21)

Proximal sesamoid bones fractures

Proximal sesamoid bone fractures are the most common fracture of all the bones in the forelimb. (6) Research of Anthenill et al. (2007)(22) showed a significantly higher risk for horses with higher exercise intensities, with higher cumulative distances and horses that had longer periods of continuous activity to have a fatal proximal sesamoid fracture. An in-vitro biomechanical study(23) of cadaver limbs supports this mechanism of training-induced effects on proximal sesamoid bones fractures. These studies suggest that intensive training strengthens the suspensory ligament, whereby the proximal sesamoid bones turn out to be the weakest point of the suspensory apparatus.(24) A study of Young et al.(1991)(25) showed differences in the bone between trained and untrained horses, whereby trained horses had significantly lower porosities and greater trabecular width compared to the control group. Also, the trained group had significantly larger mineralizing surfaces than the control group. With this knowledge, an alternative explanation could be that changes within the proximal sesamoids bones of trained horses make them more susceptible to fractures.

Bone density patterns

Subchondral bone adapts as a result of race training.(17) A theory which explains increasing of bone density is that, as a result of mechanical loading during exercise, horses will deposit new bone within the cancellous bone area of the epiphysis. This densification is accomplished by the formation of new lamellar bone on resting surfaces and is characterized by immature bone formed in the larger compartments of prior marrow space.(11,26) This response of bone results in decreased resorption and increased formation of bone, resulting in a net increase of the amount of bone per unit area, also called increased subchondral bone density or subchondral sclerosis. (27) Another interpretation is that heterogeneity in subchondral bone density is a result of bone resorption as a result of micro-cracks and at the same time as a result of the adaptation to exercise. Bone resorption predominates in the early phase of remodeling and removes damaged tissue, whereby the bones get areas of higher bone porosity and low density. At the same time remodeling as a result of exercise causes a higher bone density. (17)

With this knowledge, early recognition of bone density patterns may offer a method by which predictive pathological changes of fractures could be recognized before the fractures occur.

The objective of this study was to utilize computed tomography images from clinical cases to establish subchondral bone density at the articular surface in limbs with third metacarpal condylar fractures, proximal phalanx fractures and proximal sesamoid bone fractures, and to look at the differences and correlations compared to non-fractured limbs and between non-racehorses and racehorses.

The hypothesis of this research was that fractured third metacarpal bones, fractured proximal phalanx bones or fractured proximal sesamoid bones of thoroughbred racehorses would have a different bone density pattern in the articulating area between those three bones compared to non-fractured bones of thoroughbred racehorses.

Another hypothesis was that non-fractured limbs from thoroughbred racehorses would have a higher bone density and a different bone density pattern in the articulating area between the third metacarpal, the first phalanx and the proximal sesamoid bones than non-fractured limbs of non-racehorses.

Materials and methods

Experimental group

The pre-operative computed tomographic scans of the articulating surfaces of the third metacarpal bone, the proximal phalanx bone and the proximal sesamoid bones of the forelimbs of 22 thoroughbred racehorses were obtained from Newmarket Equine Hospital, United Kingdom. Seven had a third metacarpal fracture, twelve a proximal phalanx fracture and three a sesamoid bone fracture. The different kinds of fractures are shown in Table 1 to 3.

Control group

The Clinical-CT images of the control group were obtained from the Veterinary Teaching Hospital at Fort Collins, Colorado, USA and consist of 24 forelimbs of 12 quarter horses with unknown background information like age and sex. Furthermore, 18 racehorses from the fractured group were used as the control for other bones than their fractured bone. Nine were used as a control for the sesamoid bone fractures, four as the control for the third metacarpal fracture and five for the proximal phalanx fracture. The fractured limb from the racehorses was included because of the possible breed and training-induced effects on the bone.

Imaging with Analyze 12.0

The anatomical regions (third metacarpal, proximal phalanx and proximal sesamoid bones), were scanned in a clinical computed tomographic scanner. The CT data was acquired in the axial plane providing in-plane resolution of 49 x 49 µm with a slice thickness of 1 mm for thoroughbred racehorses (experimental group). Control limbs were from Quarter horse breeds with an in-plane resolution of 39 x 39 µm and a slice thickness of 1 mm. To facilitate image interpretation, the CT data from both experimental and control groups were transformed into isotropic voxels 49 µm3 and 39 µm3 respectively, and then reconstructed in order to be allowed for multi-planar and 3-D formats. An image analysis program (Analyze 12.0) generated color Clinical-CT images, whereby each color corresponds to a range of Clinical-CT pixel values (Houndsfield Units). Because of the differences in general bone density (the thoroughbred racehorses had a higher density than the control group), the color scale of the control group and racehorses differs in window level and width. The CT number in the middle of the grayscale is called the window level and the range of attenuation values included in the grayscale is called the window width. (28) To make the patterns more visible, the proportion of the level and width were the same for the racehorses and non-racehorses, resp. a 1341/1634 and 1065/1289 for the third metacarpal bone, 1068/1537 and 1195/1720 for the proximal phalanx bone and 1404/1762 and 1145/1436 for the proximal sesamoid bones.

Sections of the bones

Third metacarpal bone

A series of 1-mm 300 oblique contiguous Clinical-CT images of various levels of the distal 25 mm of the metacarpal condyle were obtained throughout the joint surfaces from all forelimbs. The 300-

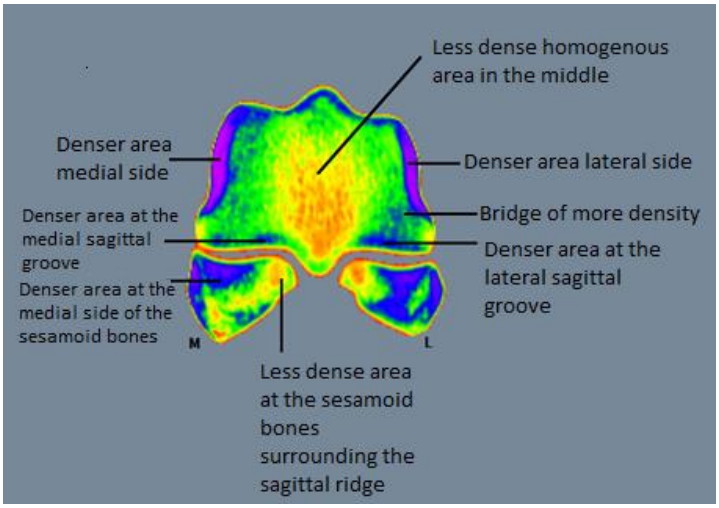

Figure 1 The different variables used to recognize the bone density patterns of the Third metacarpal bone.

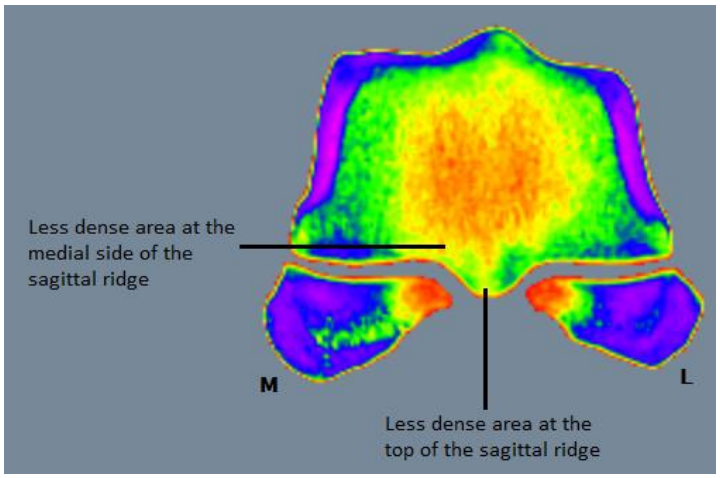

Figure 2 Two of the variables used to recognize the bone density patterns of the Third metacarpal bone.

Figure 3 The color scale of the CT images. The less dense area is red, on the left side of this bar and the denser area is purple, on the right side of this bar.

oblique plane was chosen to show the articulating surface with the proximal sesamoid bones. From every third metacarpal bone, the images at 5, 10, 15, 20 and 25 mm were used for analyzing the different variables. The variables that were analyzed in terms of absence or presence at a given level were 1) a denser area at the medial and lateral side caused by different tendons passing here, 2) a denser area at the medial or lateral sagittal groove, due to the articulation with the proximal

sesamoid bones; previous research showed a denser area on this side (4,5,12,22,26), 3) a less dense, homogenous area in the middle of the third metacarpal bone, this is the region where condylar fractures pass through, 4) a less dense or denser area at the top of the sagittal ridge, because previous research found a lower density on the ridge compared to the sagittal grooves (10), 5) a less dense area at the medial or lateral side of the sagittal ridge, because previous research showed a denser area at the sagittal grooves and a less dense area at the sagittal ridge (10), this could be an important transition area between those two different bone densities, 6) a bridge of more density between the denser area at the medial or sagittal groove to the medial or lateral side. The reason that this variable was chosen was to see if there would be a connection between the denser area in the sagittal grooves and condylar fractures. Furthermore, a denser area of the proximal phalanx at the medial or lateral side and a less dense area of the proximal phalanx surrounding the sagittal ridge and groove of the third metacarpal bone were analyzed because of the effect of the articulation of the proximal phalanx on the third metacarpal bone. The chosen variables are shown in Figure 1 and Figure 2.When the area is denser, it means that the area is more to the right on the color scale, shown in Figure 3, while a less dense area means that the area is more to the left. The more and less dense areas are compared to the general color in the bone. The absence or presence of every variable was noted.

Proximal phalanx

Scans of the proximal phalanges were obtained through the joint surfaces from all forelimbs. From every proximal phalanx bone, scans at 5, 10, 15 and 20 mm from the proximal surface were used for analyzing the different variables. The variables classified as present or absent were 1) a denser area at the medial, lateral and dorsal side, 2) a less dense area in the middle of the proximal side, 3) a less dense area at the medio- or lateroproximal side, 4) a less dense area in the middle of the dorsal side, 5) a less dense area at the medio- or laterodorsal side and 6) a homogenous less dense area in the middle

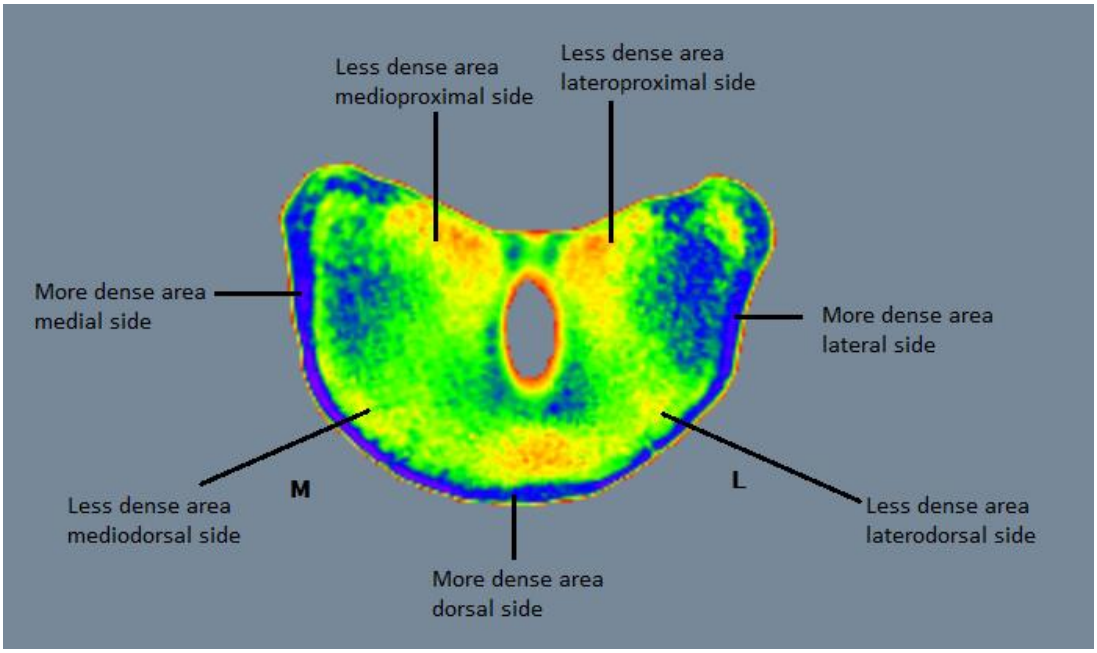

Figure 4 The variables used to characterize the bone density pattern of the proximal phalanx, only two variables are missing: the less dense area in the middle of the proximal side, which is in between the less dense area at the medioproximal and lateroproximal side. Further, the homogenous less dense area in the middle of the bone is not depicted.

of the bone. All these variables were chosen to show the effect of the forces exerted by the sagittal ridge of the third metacarpal bone on the different parts of the proximal phalanx. From every variable, the absence or presence was noted. The included variables are shown in Figure 4.

Number	Fracture
1	Complete nondisplaced lateral condylar fracture
2	Complete nondisplaced medial condylar fracture
3	Complete nondisplaced lateral condylar fracture
4	Complete nondisplaced lateral condylar fracture
5	Complete nondisplaced medial condylar fracture
6	Incomplete lateral condylar fracture
7	Complete nondisplaced lateral condylar fracture

Table 1 Fractures in horses with third metacarpal bone fracture.

Number	Fracture
1	Sagittal plane incomplete proximal phalanx fracture
2	Sagittal plane incomplete proximal phalanx fracture
3	Sagittal plane incomplete proximal phalanx fracture
4	Sagittal plane incomplete proximal phalanx fracture
5	Sagittal plane incomplete proximal phalanx fracture
6	Sagittal plane incomplete proximal phalanx fracture
7	Sagittal plane incomplete proximal phalanx fracture
8	Sagittal plane complete comminuted proximal phalanx fracture with frontal component
9	Sagittal plane complete nondisplaced proximal phalanx fracture, drill holes present
10	Sagittal plane complete minimally displaced proximal phalanx fracture
11	Sagittal plane complete, comminuted distally, proximal phalanx fracture with minimal displacement
12	Complete medial proximal eminence proximal phalanx fracture

Table 2 Fractures in horses with proximal phalanx fractures.

Number	Fracture
1	Biaxial midbody sesamoid fractures
2	Lateral midbody sesamoid fracture
3	Lateral basilar sesamoid fracture with comminution abaxially

Table 3 Fractures in horses with proximal sesamoid bone fractures

Proximal sesamoid bones

A series of 1-mm transverse and dorsal contiguous Clinical-CT images of the whole sesamoid bones was obtained throughout the joint surfaces from all forelimbs. From every proximal sesamoid bone, the transverse slides of 5, 10, 15, 20 and 25 mm and the dorsal slides of 5, 10 and 15 mm were used for analyzing the different variables. The analyzed variables in the transverse plane that were classified as present or absent were 1) a denser area at the medial, lateral or palmar side because of the possible effect on the bone of the sesamoidean and suspensory ligaments and 2) a less dense line from the proximal side, which faces the third metacarpal bone, to the distopalmar side of the bone. The reason this variable was chosen was because differences in direction or density in the middle of the bone could make a difference in the cause of fractures. Furthermore, the analyzed variables in the dorsal plane were: 1) a lower density at the top of the bone, because apical fractures are most common in proximal sesamoid bones (5), 2) a lower or higher density where the bones are facing each other, because this is the side of the bone which articulates with the sagittal ridge of the third metacarpal, 3) a higher density at the medial compared to the lateral side because of the possible effects of the sesamoidean and suspensory ligaments on the bone and 4) a higher density at the bottom of the bone, because this area faces the third metacarpal bone. From every variable, the absence or presence was noted. The included variables are also shown in Figure 5 and Figure 6.

The correct orientation of the different sides in this study was verified by the study of Becatti et al. (2014)(29) that indicates that the medial proximal sesamoid bone is wider than the lateral proximal sesamoid bones.

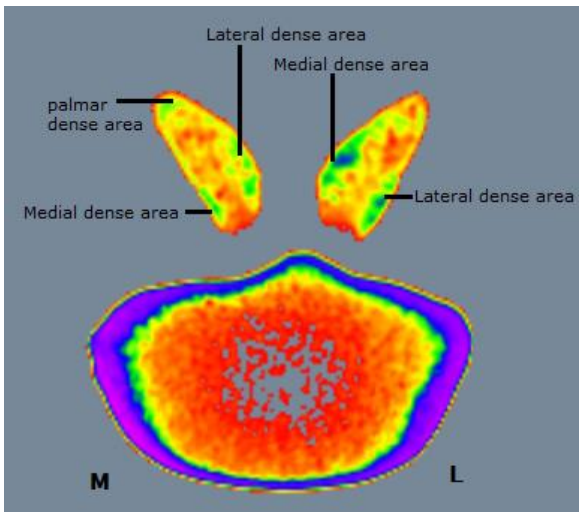

Figure 5 The transverse plane of the proximal sesamoid bone which shows the different variables that were used to characterize the bone density pattern in the proximal sesamoid bones.

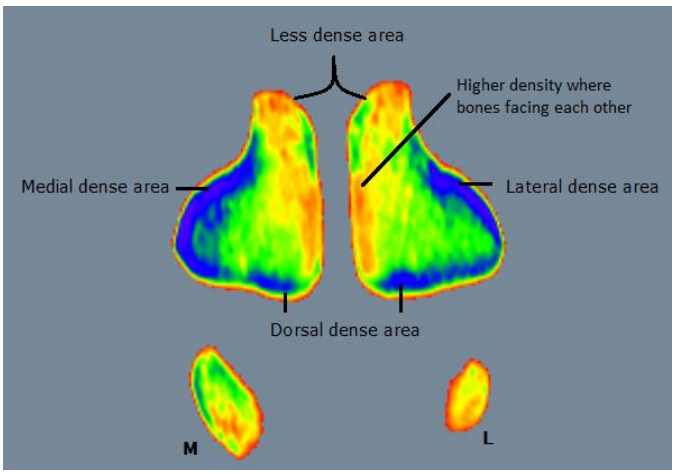

Figure 6 The dorsal plane of the proximal sesamoid bone in the first control shows the different variables that were used to characterize the bone density pattern in the proximal sesamoid bones.

Data analysis

The group of racehorses was compared with the group of non-racehorses, using Fisher's exact test to establish the statistical significance of differences. The P-value was established at 5%. Also, the Fisher's exact test was used to establish the statistical significance of differences between non-fractured and fractured limbs, left and right and the medial and lateral proximal sesamoid bones.

Results

No third metacarpal, proximal phalanx or proximal sesamoid bones were excluded from the analysis. Final group numbers to compare racehorses and non-racehorses were n=36 for the third metacarpal bone, n=21 for the proximal phalanx and n=36 for the proximal sesamoid bones. Final group numbers to compare the fractured and non-fractured bones were n=12 for the third metacarpal bone, n=17 for the proximal phalanx and n=24 for the proximal sesamoid bones. From the seven fractured third metacarpal bones, five had a lateral condylar fracture and two a medial condylar fracture. From the twelve fractured proximal phalanx bones, seven had an incomplete sagittal plane fracture, five a complete sagittal fracture and one a complete medial proximal fracture. The three fractured proximal sesamoid bones included one horse with biaxial midbody sesamoid fractures, one with a lateral midbody sesamoid fracture and one with a lateral basilar sesamoid fracture with comminution abaxially. Details on the different fractures are given in Table 1 to 3.

Third metacarpal bone

In 36 third metacarpal bones, including 24 of non-racehorses and 12 of racehorses, there was a noticeable difference in bone density pattern in eight variables. When comparing between non-racehorses and racehorses, non-racehorses had more often a denser area at the medial (P=0.008) and lateral (P=0.000) side at the 5 mm transverse level. Racehorses had more often a denser area at the medial sagittal groove at 5 mm (P=0,001) and at the lateral sagittal groove at 5 mm (P=0.000). Racehorses had less often a less dense homogenous area in the middle of the third metacarpal bone at 15 mm (p=0.000), 20 mm (p=0.000) and 25 mm (p=0.031). Another significant difference is the density at the top of the sagittal ridge, where racehorses had a less dense area at the top at 5 mm (p=0.000) and non-racehorses a denser area at the top at 5 mm (p=0.000). A bridge of more density from the denser area of the medial sagittal groove to the medial side is more often present in racehorses at 5 mm (p=0.031) and 15 mm (P=0.029) and a bridge from the denser area at the lateral sagittal groove to the lateral side is also more often present in racehorses at 5 mm (p=0.002) and 15 mm (p=0.003). Outcome for the different variables and p-values for the comparison between non-racehorses and racehorses in the third metacarpal bone are shown in Table 4. No significant differences were observed between the fractured and non-fractured third metacarpal bones and between the left and right limb.

Proximal phalanx

Concerning the 41 proximal phalanx bones, including 24 of non-racehorses and 17 of racehorses, significant differences were found in 6 variables. A less dense area in the middle of the proximal side was more often present in non-racehorses at 5 mm (p=0.000), 10 mm (p=0.024) and 15 mm (p=0.008) compared to racehorses. Also, racehorses more often had a less dense area at the lateroproximal side at 5 mm (p=0.033) compared to non-racehorses. Non-racehorses more often showed at 5 mm (p=0.005) and 10 mm (p=0.001) a less dense area in the middle of the dorsal side. While non-racehorses more often had a less dense area at the mediodorsal at 10 mm (p=0.028), racehorses showed this feature more often at 20 mm (p=0.003). A similar phenomenon occurred with another variable, where at 10 mm (p=0.001) non-racehorses more often had a less dense area at the laterodorsal side and at 20 mm (P=0.024) it were the racehorses that showed this. A homogenous less dense area in the middle of the bone was more often present in non-racehorses at 15 mm (p=0.001) and 20 mm (p=0.003) compared

to racehorses. Table 5 summarizes these results.

When comparing twelve non-fractured and five fractured proximal phalanx bones of racehorses (N=17) significant differences were shown in three variables. Racehorses with fractures showed less often a less dense area in the middle of the dorsal side at 5 mm (p=0.010) and 15 mm (p=0.009) and a less dense area at the mediodorsal side (p=0.001) and laterodorsal side (p=0.053). A homogenous less dense area in the middle of the bone was more often seen at 15 mm (p=0.044) in racehorses without fractures compared to racehorses with fractures. A summary of the significant differences and p-values between non-fractured and fractured third metacarpal bones is shown in Table 6. No significant differences were shown between the left and right limbs.

Proximal sesamoid bones

In 72 proximal sesamoid bones, including 48 of non-racehorses and 24 of racehorses, there was a noticeable difference in subchondral bone density pattern in nine variables. A denser area at 25 mm was more visible at the medial side (p=0.040) and the lateral side (p=0.001) in racehorses compared to non-racehorses in the transverse plane of the proximal sesamoid bones. A denser area at the palmar side was more often present in non-racehorses at 5 mm (p=0.023) compared to racehorses in the transverse plane. Also, a line of less density from the proximal side to the distopalmar side in the transverse plane was seen more often in non-racehorses at 5 mm (p=0.034) and 25 mm (p=0.019). A lower density where the proximal sesamoid bones faced each other was more present in non-racehorses at 5 mm (p=0.000), 10 mm (p=0.000) and 15 mm (p=0.019) and a higher density where the proximal sesamoid bones faced each other was more often present in racehorses at 10 mm (p=0.000) and 15 mm (P=0.000). Remarkable is that a higher density at the bottom of the bone is more present in non-racehorses at 5 mm (p=0.001) and in racehorses at 15 mm (p=0.006) in the dorsal plane (Table 7).

Noticeable differences between 18 non-fractured and 6 fractured proximal sesamoid bones were found in three variables. Racehorses with fractures more often showed a higher density where bones face each other at 5 mm (p=0.038) and racehorses with fractures more often showed a lower density where bones faced each other at 15 mm (p=0.001) (Table 8).

In the comparison of the proximal sesamoid bones of the left and right limb no significant differences were found. In the control group of non-racehorses, at 20 mm the medial proximal sesamoid bone shows more often a denser area at the medial side compared to the lateral proximal sesamoid bone (p=0.023). Non-racehorses more often showed a denser area at the medial side of the medial proximal sesamoid bone compared to the lateral proximal sesamoid bone (p=0.001), while the lateral proximal sesamoid bone more often showed a denser area at the lateral side (p=0.030). Within the control group of racehorses and the group of fractured limbs, no significant differences between the medial and lateral proximal sesamoid bones were present.

Level of the scan / Variable	5 mm	10 mm	15 mm	20 mm	25 mm
Denser area at the medial side (N=36)	P = 0.008 (8/12 present in racehorses, 0/12 in racehorses)	A constant (all present)	A constant (all present)	A constant (all present)	A constant (all present)
Denser area at the lateral side	P = 0.000 (5/12 present in racehorses,0/12 in racehorses)	A constant (all present)	A constant (all present)	A constant (all present)	P=0.333 (11/12 present in racehorses)
Denser area at the medial sagittal groove	P = 0.001 (8/24 present in non-racehorses, 0/12 in racehorses)	P=0.079 (18/24 present in non-racehorses, 12/12 in racehorses)	P=0.536 (21/24. present in non-racehorses, 0/12 in racehorses)	A constant (all present)	P=1.000 (21/24 present in non-racehorses, 11/12 present in racehorses)
Less dense homogenous area in the middle of the third metacarpal bone	P=0.333 (24/24 present in non-racehorses, 4/12 present in racehorses)	P=0.098 (23/24 present in non-racehorses, 9/12 in racehorses)	P=0.000 (24/24 present in non-racehorses, 4/12 in racehorses)	P= 0.000 24/24 present in non-racehorses, 5/12 in racehorses	P=0.031 (24/24 present in non-racehorses, 9/12 in racehorses)
Denser area at the lateral sagittal groove	P = 0.000 (4/24 present in non-racehorses, 0/12 in racehorses)	P=0.016 (15/24 present in non-racehorses, 12/12 present in racehorses)	P=1.000 (1/24 present in non-racehorses, 12/12 present in racehorses)	P=1.000 (1/24 present in non-racehorses, 12/12 present in racehorses)	P=0.536 (21/24 present in non-racehorses, 12/12 in racehorses)
Less dense area at the top of the sagittal ridge	P=0.000 (7/24 present in non-racehorses, 0/12 in racehorses)	P=0.219 (16/24 present in non-racehorses, 11/12 present in racehorses)	P=1.000 24/24 present in non-racehorses, 11/12 present in racehorses)	P=1.000 (22/24 present in non-racehorses, 11/12 in racehorses)	P=0.247 (19/24 present in non-racehorses, 7/12 in racehorses)
Denser area at the top of the sagittal ridge	P=0.000 (17/24 present in non-racehorses, 0/12 in racehorses)	P=0.115 (9/24 present in non-racehorses, 1/12 in racehorses)	P=0.646 (4/20 present in non-racehorses, 1/12 in racehorses)	P=0.253 (1/24 present in non-racehorses, 2/12 in racehorses)	P=0.247 19/24 present in non-racehorses, 7/12 in racehorses)
Bridge of less density from the less dense area at the medial sagittal groove to the medial side	P=0.031 (3/12 present in racehorses, 0/24 in non-racehorses)	P=0.020 (4/24 present in non-racehorses, 7/12 present in racehorses)	P=0.029 (8/12 present in racehorses, 6/24 in non-racehorses)	P=1.000 (7/12 present in racehorses, 13/24 in non-racehorses)	P=1.000 (9/12 present in racehorses, 19/24 in non-racehorses)
Bridge of less density from the less dense area at the lateral sagittal groove to the lateral side	P=0.002 (5/12 present in racehorses, 0/24 present in non-racehorses)	P=0.158 (9/24 present in non-racehorses, 8/12 present in racehorses)	P=0.003 (9/12 present in racehorses, 5/24 present in non-racehorses)	P=0.081 (8/12 present in racehorses, 8/24 in non-racehorses)	P=0.289 (8/12 present in racehorses, 10/24 in non-racehorses)

Table 4 P-values of the different variables of the third metacarpal bone (N=36). Comparison between racehorses (N=24) and non-racehorses (N=12). This table shows that racehorses had significantly more often a dense area at the medial and lateral sagittal groove and a bridge from the lateral and medial sagittal groove to the resp. medial and lateral side in the third metacarpal bone. This table further shows that non-racehorses had significantly more often a denser area at the medial and lateral side and a less dense homogenous area in the middle of the third metacarpal bone.

Level of the scan / Variable	5 mm	10 mm	15 mm	20 mm
Less dense in the middle of the proximal side	P=0.000 (22/24 present in nonracehorses, 6/17 in racehorses)	P=0.024 (24/24 present in non-racehorses, 13/17 in racehorses)	P=0.008 (24/24 present in non-racehorses, 5/17 in racehorses)	P=0.064 (24/24 present in non-racehorses, 14/17 in racehorses)
Less dense area at the lateroproximal side	P=0.033 (18/24 present in nonracehorses, 17/17 present in racehorses)	P=0.152 (16/24 present in nonracehorses, 15/17 in racehorses)	P=0.502 (22/24 present in non-racehorses, 17/17 in racehorses)	A constant (all present)
Less dense area in the middle of the dorsal side	P=0.005 (18/24 present in nonracehorses, 5/17 in racehorses)	P=0.001 (23/24 present in nonracehorses, 8/17 in racehorses)	P=0.358 (15/24 present in non-racehorses,8/17 in racehorses)	A constant (all present)
Less dense area at the mediodorsal side	P=0.065 (19/24 present in non-racehorses, 17/17 present in racehorses)	P=0.028 (9/15 present in nonracehorses, 1/17 present in racehorses)	A constant (not present)	P=0.003 (0/24 present in nonracehorses, 11/17 present in racehorses)
Less dense area at the laterodorsal side	P=1.000 (23/24 present in nonracehorses, 17/17 present in racehorses)	P=0.001 (19/24 present in nonracehorses, 4/17 present in racehorses	P=1.000 (1/24 present in nonracehorses, 0/17 present in racehorses)	P=0.024 (0/24 present in nonracehorses, 4/17 present in racehorses)
Homogenous less dense area in the middle of the bone	A constant (not present)	P=0.065 (5/24 present in non-racehorses, 0/17 present in racehorses)	P=0.001 (24/24 present in non-racehorses, 10/17 present in racehorses)	P=0.003 (24/24 present in non-racehorses, 11/17 present in racehorses)

Table 5 P-values of the different variables of the proximal phalanx bone. Comparison of racehorses (N=17) vs non-racehorses. (N=24) This table shows that racehorses had significantly more often a less dense area at the lateroproximal side and non-racehorses had significantly more often a less dense area in the middle of the proximal articular surface and dorsal side and a homogeneous less dense area in the middle of the proximal phalanx.

Level of the scan / Variable	5 mm	10 mm	15 mm	20 mm
Less dense area in the middle of the dorsal side	P=0.010 (4/5 present in racehorses without fractures, 1/12 in racehorses with fractures)	P=0.131 (4/5 present in racehorses without fractures, 4/12 in racehorses with fractures)	P=0.009 (5/5 present in racehorses without fractures, 3/12 present in racehorses with fractures)	P=0.261 (0/5 present in racehorses without fractures, 4/8 present in racehorses with fractures)
Less dense area at the mediodorsal side	A constant (all present)	P=1.000 (0/5 present in racehorses without fractures, 1/12 present in racehorses with fractures)	A constant (not present)	P=0.001 (5/5 present in racehorses without fractures, 1/12 present in racehorses with fractures)
Less dense area at the laterodorsal side	A constant (all present)	P=0.538 (2/5 present in racehorses without fractures, 2/12 present in racehorses with fractures)	A constant (not present)	P=0.053 (3/5 present in racehorses without fractures, 1/12 present in racehorses with fractures)
Homogenous less dense area in the middle of the bone	A constant (not present)	A constant (not present)	P=0.044 (5/5 present in racehorses without fractures, 5/12 present in racehorses with fractures)	P=0.102 (5/5 present in racehorses without fractures, 6/12 present in racehorses with fractures)

Table 6 P-values of the different variables of the proximal phalanx. Comparison between racehorses without fractures (N=5) and racehorses with fractures (N=12). This table shows that non- fractured limbs had significantly more often a less dense area in the middle of the dorsal and mediodorsal side and a homogenous less dense area in the middle of the proximal phalanx bone.

Level of the scan / Variable	5 mm	10 mm		15 mm	
Denser area at the medial side	P=0.659 (44/48 present in non-racehorses, 23/24 present in racehorses)	P=1.000 (45/48 present in non-racehorses, 23/24 present in racehorses)	P=1.000 (45/48 present in non-racehorses, 23/24 present in racehorses)	P=0.316 (39/48 present in nonracehorses, 22/24 present in racehorses)	P=0.040 (33/48 present in nonracehorses, 22/24 present in racehorses)
Denser area at the lateral side	P=0.479 (40/48 present in non-racehorses, 22/24 present in racehorses)	P=1.000 (47/48 present in non-racehorses, 24/24 present in racehorses)	P=1.000 (47/48 present in non-racehorses, 24/24 present in racehorses)	P=0.169 (42/48 present in non-racehorses, 24/24 present in racehorses)	P=0.001 (32/48 present in non-racehorses, 24/24 present in racehorses)
Denser area at the palmar side (Transverse plane)	P= 0.023 (31/48 present in non-racehorses, 8/24 present in racehorses)	P=0.087 (7/48 present in nonracehorses, 0/24 present in racehorses)	P=0.087 (7/48 present in nonracehorses, 0/24 present in racehorses)	P=0.659 (4/48 present in nonracehorses, 1/24 present in racehorses)	P=1.000 (1/48 present in non-racehorses, 0/24 present in racehorses)
Less density line from the proximal side to the distopalmar side (Transverse plane)	P=0.034 (48/48 present in non-racehorses, 21/24 present in racehorses)	P=0.333 (48/48 present in non-racehorses, 23/24 present in racehorses)	P=0.333 (48/48 present in non-racehorses, 23/24 present in racehorses)	P=0.333 (48/48 present in non-racehorses, 23/24 present in racehorses)	P=0.019 (26/48 present in non-racehorses, 11/24 present in racehorses)
Lower density where bones facing each other	P=0.000 (44/48 present in non-racehorses, 23/24 present in racehorses)	P=0.010 (40/48 present in non-racehorses, 4/24 present in racehorses)	P=0.019 (22/48 present in nonracehorses, 4/24 present in racehorses)	-	-
Higher density where bones facing each other	P=0.659 (0/48 present in non-racehorses, 7/24 present in racehorses)	P=0.000 (10/48 present in non-racehorses, 22/24 present in racehorses)	P=0.000 (17/48 present in non-racehorses, 22/24 present in racehorses)	-	-
Higher density at the bottom of the bone	P=0.001 (40/48 present in non-racehorses, 10/24 present in racehorses)	P=0.063 (29/48 present in nonracehorses, 20/24 present in racehorses)	P=0.006 (19/48 present in nonracehorses, 18/24 present in racehorses)	-	-

Table 7 P-values of the different variables of the proximal sesamoid bones. Comparison between racehorses (48 proximal sesamoid bones) and non-racehorses (24 proximal sesamoid bones). This table shows that racehorses had significantly more often a denser area at the medial and lateral side and a higher density where the bones where facing each other. It also shows that non-racehorses had significantly more often a denser area at the palmar side and a lower density where the proximal sesamoid bones are facing each other in the proximal sesamoid bones. A higher density at the bottom of the bone is more present in non-racehorses at 5 mm and in racehorses at 15 mm.

Level of the scan / Variable	5 mm	10 mm	15 mm
Lower density at the top of the bone	P=0.251 (16/18 present in racehorses without fractures, 4/6 present in racehorses with fractures)	P=0.054 (18/18 present in racehorses without fractures, 4/6 present in racehorses with fractures)	P=0.250 (18/18 present in racehorses without fractures, 5/6 present in racehorses with fractures)
Lower density where bones facing each other	P=1.000 (17/18 present in racehorses without fractures, 6/6 present in racehorses with fractures.	P=0.251 (2/18 present in racehorses without fractures, 2/6 present in racehorses with fractures)	P=0.001 (0/18 present in racehorses without fractures, 4/6 present in racehorses with fractures)
Higher density where bones facing each other	P=0.038 (3/18 present in racehorses without fractures, 4/6 present in racehorses with fractures	P=1.000 (16/18 present in racehorses without fractures, 6/6 present in racehorses with fractures)	P=0.054 (18/18 present in racehorses without fractures, 2/6 present in racehorses with fractures)

Table 8 P-values of the different variables of the proximal sesamoid bones. Comparison between racehorses without fractures (N=18) and racehorses with fractures (N=6). The table shows that racehorses with fractures had significantly more often a lower density where the bones are facing each other at 15 mm and a higher density at 5mm.

Discussion

If prior pathological changes of fractures could be recognized, we could make a big step to prevent bones from being fractured. This study found differences in bone density between non-racehorses and racehorses 1) at the medial and lateral side, the medial and lateral sagittal groove, in the middle of the bone, at the top of the sagittal ridge and in the area of the medial and lateral sagittal groove to the medial and lateral side of the third metacarpal bone, 2) at the middle of the proximal side, the lateroproximal side, the middle of the dorsal side, the mediodorsal and laterodorsal side and in the middle of the proximal phalanx bone and 3) at the medial, lateral and palmar side, from the proximal side to the distopalmar side, the area where the bones are facing each other and at the bottom of the proximal sesamoid bones. This paper also shows differences between non-fractured and fractured limbs 1) at the dorsal side, the medio- and laterodorsal side and in the middle of the proximal phalanx bone, 2) at the top of the bone and 3) at the place where the bones face each other of the proximal sesamoid bones.

Comparison results with literature data

Third metacarpal bone

This research showed a denser area at the medial and lateral side of the third metacarpal bone in non-racehorses at 5 mm, deeper in the bone there was no significant difference and this area was present in non-racehorses and racehorses. To the author's knowledge, no previous studies were performed regarding the bone density on this specific area in the third metacarpal bone of horses so these results cannot be compared with other results. A suggestion for the cause of the higher density at this area through the bone may be that the interosseous muscle experiences large strains(22) and that this structure exerts forces on the medial and lateral side of the third metacarpal bone, which can cause changes in bone density.

The differences at the medial and lateral sagittal groove between the non-racehorses and racehorses in the third metacarpal bone were similar to those reported in previous studies. (4,5,12,22,26) A suggestion for the cause of the higher density in the palmar regions of the condyle in racehorses is the articulation of the condyles with the proximal sesamoid bones which is subject to considerable forces in the stance phase of the gallop.

This could cause adaptive responses of the bone, resulting in a higher bone density. (4,10)

In this paper, thoroughbred racehorses had a less dense area at the top of the sagittal ridge compared to non-racehorses. A study by Riggs et al. (1999)(10)also found a zone of low density bone at the sagittal ridge and suggests that the contact between the sagittal ridge and the intersesamoidean ligament could be the reason that there is less stress on the sagittal ridge. (10) The fact that the intersesamoidean ligament is less strong and thick in non-racehorses compared to racehorses might cause it to be a less effective shock breaker.

To the author's knowledge, research regarding the bone density in the middle of the third metacarpal has never been performed before. According to the present study non-racehorses more often had a less dense, homogenous area in the middle of the third metacarpal compared to racehorses. Racehorses more often had a heterogeneous area in the middle of the bone, which may be explained by the adaptive response of bone to training. A combination of bone resorption, as a result of microcracks, and bone adaptation as a result of exercise may be a reason for heterogeneity in the third metacarpal bone. (19)

A bridge of higher density from the denser area at the medial sagittal groove to the medial side and a bridge of higher density from the denser area at the lateral sagittal groove to the lateral side were more present in racehorses compared to non-racehorses. No previous studies were performed earlier on this specific area. The bridge may be explained by the external forces of the proximal sesamoid bones and the interosseous tendon, which make the bone adaptive to the exercise.

Proximal phalanx

Non-racehorses more often had a less dense area in the middle of the proximal phalanx. These results are similar to those reported in a previous study, where a higher bone density was found in the central and palmar sagittal groove of racehorses compared to non-racehorses.(17) The present study found that the dorsal side of the proximal phalanx had a higher density as well; suggesting that that the whole sagittal groove of the proximal phalanx endures a higher load during races. Although the research of Noble et al. (2016) found that the lateral and sagittal ridge of the sagittal groove is less dense compared to the middle of the sagittal groove, the current study more often found a less dense area at the lateroproximal, the laterodorsal and mediodorsal side of the proximal phalanx of racehorses. It is worth noting that non-racehorses more often had a less dense area at the mediodorsal side at 10 mm and at 20 mm at the laterodorsal side.

A similar result was shown in the proximal phalanx as in the third metacarpal bone. Non-racehorses more often had a less dense area in the middle of the bone compared to racehorses, which can be explained by the adaptation to exercise of the racehorses. (17)

Fractured vs. non-fractured

Racehorses with fractures less often show a less dense area in the middle of the dorsal side, the mediodorsal side and the laterodorsal side. The fractures occur mostly in the sagittal plane at the proximal sagittal groove. (15,16) A higher bone density could make the bone stiffer (2,10,11) and in combination with the compressive and torsional forces (17,18) on the proximal phalanx, this might make this area in the proximal phalanx prone to fractures.

This paper shows that racehorses without fractures more often have a less dense area

in the middle of the bone compared to racehorses with fractures. The sagittal groove of the proximal phalanx adapts to exercise (16), which could cause a higher bone density but at the same time microcracks may activate bone resorption. This results in more heterogeneity in the bone. In the early phase of remodeling and removing damaged tissue this bone resorption predominates, but at the same time compressive and torsional forces continue to work on the bone. This could result in the bone fracturing.

Proximal sesamoid bones

This study found a denser area at the medial side of the medial proximal sesamoid bone and a denser area at the lateral side of the lateral proximal sesamoid bone in non-racehorses. The abaxial location of the thick branch of the interosseous (30) might be the reason for a denser area on the medial and lateral side of the medial and lateral proximal sesamoid bone, respectively. Racehorses more often show a denser area at the medial and lateral side, which might be explained by the effect of the thick branch of the interosseous on the bone.

A result of this study is a denser area at the palmar side in non-racehorses compared to racehorses. The flexor tendons face the palmar side of the bone (30) which might play a role in the denser area at this side.

This paper shows a lower density at the site where the bones face each other in non-racehorses and a higher density in racehorses. During hyperextension of the fetlock the proximal sesamoid bones slide below the condyle at the sides of the sagittal ridge and the palmar ligament extends its bearing surface to reduce the effect of the flexor tendons on this movement. (20-22) This study suggests that this mechanism apparently does not work as well anymore in racehorses, which might trigger a higher resistance during this movement. This higher resistance causes an adaptive response of the bone which results in a higher bone density.

Fractured vs non- fractured

Apical fractures are the most common fractures in the proximal sesamoid bones.(5) This research shows that racehorses without fractures more often have a lower density at the top of the bone compared to racehorses with fractures. The relative less dense top suggests that adapted bone at the top of the bone might be a cause of fractures in proximal sesamoid bones, but in this study only midbody fractures were included. With this knowledge, the transition of the denser top to the less dense midbody might be related to fractures in the proximal sesamoid bone.

When comparing the surface where the bones face each other between racehorses without fractures and racehorses with fractures, this paper found a higher density in racehorses without fractures and a lower density in racehorses with fractures. The reason for this might be an adaptive response to exercise in the bones without fractures, which makes the bones stronger. The fractured bones still have a lower density and might be more prone to fractures.

Limitation of the study

The control group in this research included 24 Clinical CT scans of quarter horses from New Market Equine Hospital in the UK. When comparing these with Clinical CT scans of 22 thoroughbred racehorses from the Veterinary Teaching Hospital, a lot of differences between those two groups could be noted. First, the clinical CTs are different and could not be converted to the same standards, for example the same color scale. Another reason that the images could not be compared one-to-one is the difference in general bone density between non-racehorses and racehorses, where

racehorses in general have a higher density. A possibility to avoid this is to use a calibration phantom with a bubble filled with water, a piece of bovine hydroxyapatite, and a defect filled with air during the CT scans. This can help to determine the different Hounsfield Unit values for water, bone and air and makes comparison easier. In the current study it has been attempted to make the color scale as clear as possible, to make the bone density patterns visible in the best possible way. But still, there will always be differences in color scale, precluding an objective, quantitative comparison.

In this study, the control group is from the United States of America and the experimental group from the United Kingdom. This is relevant, because a study of Jacklin and Wright (2012) showed differences in third metacarpal fractures between racehorses in the United Kingdom and the United States. (22) A further limitation is that differences between non-racehorses and racehorses have been described without background information regarding age, sex and training intensity of the animals. This could influence the results and the differences in bone density between the different groups. A study by Loughridge et al. (2016)(12) showed that age had no significant effect on bone density. However, sex does appear to have a significant effect. Another study (5) showed no effect of age, length of career or number of career starts in UK racehorses.

Because the number of horses is low in this investigation, especially in the racehorses with fractures, already a small change in outcome causes a change in the p-value. To the author's knowledge, many of the areas which were compared in this study have not been compared before. This makes comparison with earlier studies of larger size impossible.

In this research, only the author has analyzed the different variables in the CT images, which may have introduced a bias. Randomization of the different CT images was impossible, because the fracture is visible in the image. This could have influenced the author when giving value to the different variables.

In this research there were no significant differences between the left and right forelimb in the control group. Previous studies have identified differences in the prevalence of lateral condylar fracture in left and right forelimbs. Furthermore, certain studies have reported more fractures occurring on the left forelimb, (9,31,32) while other studies reported more fractures occurring on the right forelimb(24,33) Because this information was unknown for the fractured limbs used in this paper, a comparison with other research was impossible.

Conclusion and Clinical Relevance

There was a significant difference in bone mineral density of the articular surface between the fractured and non-fractured limb and the non-racehorses and racehorses in this paper. This paper is hence a first step towards finding a way to recognize bone density patterns to prevent fractures in the metacarpophalangeal joint. However, due to the limitations of this study more research regarding this subject remains necessary.

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Attachments

Table 9: Data of the variables of the Third metacarpal bones at 5 mm transverse plane. A 1 means that the variable is present, a 0 that the variable is absent.

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J	*K	*L	*M	*N	*O
1	Left	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
1	Right	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
2	Left	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
2	Right	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
3	Left	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
3	Right	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
4	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
4	Right	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
5	Left	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1
5	Right	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1
6	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
6	Right	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
7	Left	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
7	Right	1	1	0	0	1	0	1	0	0	0	0	1	1	1	1
9	Left	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1
9	Right	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1
10	Left	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
10	Right	1	1	0	0	1	0	1	0	0	0	0	1	1	1	1
14	Left	1	1	1	0	1	1	0	0	0	0	0	1	1	1	1
14	Right	1	1	1	0	1	1	0	0	1	0	0	1	1	1	1
16	Left	1	1	0	1	1	0	1	1	0	0	0	1	1	1	1
16	Right	1	1	0	0	1	0	1	0	1	0	0	1	1	1	1
17	Left	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1
17	Right	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
Khotan	unknown	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1
Lockwood	unknown	0	0	1	1	1	1	0	0	1	1	1	1	1	1	1
Modun	unknown	1	0	1	1	1	1	0	0	0	0	0	1	1	1	1
Stoute Seraphina	unknown	0	0	1	1	1	1	0	0	0	0	0	1	1	1	1
Amber Isle	unknown	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Harjas	unknown	1	0	1	1	1	1	0	0	0	0	0	1	1	1	1
Johnston Stir	unknown	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
Magic Mystery	unknown	0	0	1	1	1	1	0	0	1	0	0	1	1	0	0
Sadaara	unknown	1	0	1	1	1	1	0	1	1	0	0	1	1	1	1
Titled Lady	unknown	1	1	0	1	1	1	0	0	1	0	0	1	1	1	1
Altruism	unknown	0	0	1	1	1	1	0	0	1	0	0	1	1	1	1
Chaparachick	unknown	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1

Table 2: Data of the variables of the Third metacarpal bones at 10 mm transverse plane. A 1 means that the variable is present, an 0 that the variable is absent.

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J	*K	*L	*M	*N	*O
1	Left	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1
1	Right	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1
2	Left	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1
2	Right	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1
3	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
3	Right	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
4	Left	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
4	Right	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1
5	Left	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1
5	Right	1	1	0	0	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
6	Left	1	1	1	1	0	0	1	0	0	0	1	1	1	1	1
6	Right	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1
7	Left	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1
7	Right	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1
9	Left	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1
9	Right	1	1	1	0	1	1	1	0	0	0	0	1	1	1	1
10	Left	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
10	Right	1	1	0	0	1	0	1	1	1	0	0	1	1	1	1
14	Left	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1
14	Right	1	1	0	0	1	1	0	1	0	0	0	1	1	1	1
16	Left	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1
16	Right	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
17	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
17	Right	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1
Khotan	unknown	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
Lockwood	unknown	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
Modun	unknown	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1
Stoute Seraphina	unknown	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
Amber Isle	unknown	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
Harjas	unknown	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1
Johnston Stir	unknown	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1
Magic Mystery	unknown	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1
Sadaara	unknown	1	1	1	1	0	1	0	0	0	1	1	unknown	unknown	unknown	unknown
Titled Lady	unknown	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
Altruism	unknown	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
Chaparachick	unknown	1	1	1	1	0	1	0	0	0	0	0	1	1	1	1

Table 3: Data of the variables of the Third metacarpal bones at 20 mm transverse plane. A 1 means that the variable is present, an 0 that the variable is absent.

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J	*K	*L	*M	*N	*O
1	Left	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
1	Right	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
2	Left	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
2	Right	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
3	Left	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
3	Right	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
4	Left	1	1	1	1	1	1	0	0	0	1	0	unknown	unknown	unknown	unknown
4	Right	1	1	1	1	1	0	1	0	0	1	1	unknown	unknown	unknown	unknown
5	Left	1	1	1	1	1	1	0	0	0	1	1	unknown	unknown	unknown	unknown
5	Right	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
6	Left	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
6	Right	1	1	1	1	1	1	0	0	0	1	1	unknown	unknown	unknown	unknown
7	Left	1	1	1	1	1	1	0	0	0	1	1	unknown	unknown	unknown	unknown
7	Right	1	1	1	0	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
9	Left	1	1	1	1	1	1	0	0	0	1	0	unknown	unknown	unknown	unknown
9	Right	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
10	Left	1	1	1	1	1	1	0	1	0	1	1	unknown	unknown	unknown	unknown
10	Right	1	1	1	1	1	1	0	1	1	1	0	unknown	unknown	unknown	unknown
14	Left	1	1	1	1	1	1	0	0	0	0	0	unknown	unknown	unknown	unknown
14	Right	1	1	1	1	1	0	0	0	0	1	1	unknown	unknown	unknown	unknown
16	Left	1	1	1	1	1	1	0	1	0	1	0	unknown	unknown	unknown	unknown
16	Right	1	1	1	1	1	1	0	0	0	1	0	unknown	unknown	unknown	unknown
17	Left	1	1	1	1	1	1	0	1	0	1	1	unknown	unknown	unknown	unknown
17	Right	1	1	1	1	1	1	0	1	0	1	1	unknown	unknown	unknown	unknown
Khotan	unknown	1	1	1	1	0	1	0	0	0	1	1	unknown	unknown	unknown	unknown
Lockwood	unknown	1	1	1	1	0	0	1	0	0	1	1	unknown	unknown	unknown	unknown
Modun	unknown	1	1	1	1	0	1	0	0	0	1	0	unknown	unknown	unknown	unknown
Stoute Seraphina	unknown	1	1	1	1	1	1	1	0	0	0	0	unknown	unknown	unknown	unknown
Amber Isle	unknown	1	1	1	1	1	1	0	0	0	1	1	unknown	unknown	unknown	unknown
Harjas	unknown	1	1	1	1	0	1	0	0	0	1	1	unknown	unknown	unknown	unknown
Johnston Stir	unknown	1	1	1	1	0	1	0	1	1	0	1	unknown	unknown	unknown	unknown
Magic Mystery	unknown	1	1	1	1	1	1	0	0	0	0	1	unknown	unknown	unknown	unknown
Sadaara	unknown	1	1	1	1	0	1	0	1	0	1	0	unknown	unknown	unknown	unknown
Titled Lady	unknown	1	1	1	1	0	1	0	0	0	0	0	unknown	unknown	unknown	unknown
Altruism	unknown	1	1	1	1	1	1	0	0	0	1	1	unknown	unknown	unknown	unknown
Chaparachick	unknown	1	1	1	1	1	1	0	0	0	0	1	unknown	unknown	unknown	unknown

Table 4: Data of the variables of the Third metacarpal bones at 25 mm transverse plane. A 1 means that the variable is present, an 0 that the variable is absent.

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J	*K	*L	*M	*N	*O
1	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
1	Right	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
2	Left	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1
2	Right	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
3	Left	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
3	Right	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
4	Left	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
4	Right	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1
5	Left	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
5	Right	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
6	Left	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1
6	Right	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
7	Left	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
7	Right	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
9	Left	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
9	Right	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
10	Left	1	1	1	1	1	1	0	1	0	1	0	1	1	1	0
10	Right	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
14	Left	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
14	Right	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1
16	Left	1	1	0	0	1	0	1	1	1	1	0	1	1	1	1
16	Right	1	1	0	0	1	1	0	0	0	1	1	1	1	1	1
17	Left	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
17	Right	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1
Khotan	unknown	1	1	1	1	0	1	0	1	0	1	1	1	1	1	1
Lockwood	unknown	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1
Modun	unknown	1	0	1	1	0	1	0	0	0	1	0	1	1	1	1
Stoute Seraphina	unknown	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1
Amber Isle	unknown	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
Harjas	unknown	1	1	0	1	0	1	0	0	0	1	0	1	1	1	1
Johnston Stir	unknown	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1
Magic Mystery	unknown	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1
Sadaara	unknown	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1
Titled Lady	unknown	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1
Altruism	unknown	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1
Chaparachick	unknown	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1

Legend table 1 to 5

*A = Denser area at the medial side
*B = Denser area at the lateral side
*C = Denser area at the medial sagittal groove
*D = Denser area at the lateral sagittal groove
*E = Less dense, homogenous area in the middle of MC3
*F = Less dense area at the top of the sagittal ridge
*G = Denser area at the top of the sagittal ridge
*H = Less dense area at the medial side of the sagittal ridge/ to the medial sagittal groove
*I = Less dense area at the lateral side of the sagittal ridge/ to the lateral sagittal groove
*J = Bridge of less density from the less dense area at the medial sagittal groove to the medial side
*K = Bridge of less density from the less dense area at the lateral sagittal groove to the lateral side
*L = Denser area of the Proximal Phalanx at medial side
*M = Denser area of the proximal Phalanx at the lateral side
*N = Less dense area at the proximal phalanx surrounding the sagittal ridge and groove of MC3 at the medial side
*O = Less dense area at the proximal phalanx surrounding the sagittal ridge and groove of MC3 at the lateral side

Table 5: 5mm proximal phalanx

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J
1	Left	1	1	1	1	1	1	0	1	1	0
1	Right	1	1	1	1	1	1	0	1	1	0
2	Left	1	1	1	1	0	0	1	0	1	0
2	Right	1	1	1	1	1	0	1	0	1	0
3	Left	1	1	1	1	1	1	1	1	1	0
3	Right	1	1	1	1	1	1	0	1	1	0
4	Left	1	1	1	1	1	1	1	1	1	0
4	Right	1	1	1	1	1	1	0	1	1	0
5	Left	1	1	1	1	1	1	1	1	1	0
5	Right	1	1	1	1	1	1	1	0	1	0
6	Left	1	1	1	1	1	1	1	1	1	0
6	Right	1	1	1	1	1	1	1	1	1	0
7	Left	1	1	1	0	1	1	1	1	1	0
7	Right	1	1	1	1	1	1	0	0	0	0
9	Left	1	1	1	1	1	1	1	1	1	0
9	Right	1	1	1	1	1	0	1	1	1	0
10	Left	1	1	1	1	1	0	1	1	1	0
10	Right	1	1	1	1	1	0	1	1	1	0
14	Left	1	1	1	1	1	1	1	1	1	0
14	Right	1	1	1	1	1	1	1	1	1	0
16	Left	1	1	1	1	1	1	1	1	1	0
16	Right	1	1	1	1	1	1	1	1	1	0
17	Left	1	1	1	1	1	1	0	0	1	0
17	Right	1	1	0	0	1	0	1	1	1	0
Altruism	unknown	1	1	1	1	1	1	1	1	1	0
Johnston Stir	unknown	1	1	1	1	1	1	1	1	1	0
Lockwood	unknown	1	1	1	0	1	1	1	1	1	0
Modun	unknown	1	1	1	0	1	1	0	1	1	0
Stoute seraphina	unknown	1	1	1	0	1	1	1	1	1	0
Coral Bee	unknown	1	1	1	1	1	1	1	1	1	0
Genius Beast	unknown	1	1	1	1	1	1	0	1	1	0
Johnston Cosquila	unknown	1	1	1	0	1	1	0	1	1	0
Johnston Jalingo	unknown	1	1	1	0	1	1	0	1	1	0
Khotan	unknown	1	1	1	0	1	1	0	1	1	0
Latch on the Blue	unknown	1	1	1	1	1	1	0	1	1	0
Michelton	unknown	1	1	1	0	1	1	0	1	1	0
Revolutionist	unknown	1	1	1	0	1	1	0	1	1	0
Walter	unknown	1	1	1	0	1	1	0	1	1	0
Amber Isle	unknown	1	1	1	1	1	1	0	1	1	0
Bergamot Orange	unknown	1	1	1	0	1	1	0	1	1	0
Camlann	unknown	1	1	1	0	1	1	0	1	1	0

Table 6: 10mm proximal phalanx

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J
1	Left	1	1	1	1	1	1	1	0	1	0
1	Right	1	1	1	1	1	0	1	1	1	0
2	Left	1	1	1	1	0	0	0	0	0	1
2	Right	1	1	1	1	0	0	1	0	1	0
3	Left	1	1	1	1	1	0	1	0	1	0
3	Right	1	1	1	1	1	1	1	0	1	0
4	Left	1	1	1	1	1	1	1	0	1	0
4	Right	1	1	1	1	1	1	1	0	1	1
5	Left	1	1	1	1	1	1	1	1	1	1
5	Right	1	1	1	1	1	1	1	1	1	1
6	Left	1	1	1	1	1	1	1	0	1	1
6	Right	1	1	1	1	1	1	1	0	1	0
7	Left	1	1	1	1	1	1	1	1	1	0
7	Right	1	1	1	1	1	1	1	1	0	0
9	Left	1	1	1	1	1	0	1	1	1	0
9	Right	1	1	1	1	1	0	1	1	1	0
10	Left	1	1	1	1	1	1	1	1	1	0
10	Right	1	1	1	1	1	1	1	1	1	0
14	Left	1	1	1	1	0	0	1	0	0	0
14	Right	1	1	1	1	1	1	1	0	0	0
16	Left	1	1	1	1	1	1	1	0	1	0
16	Right	1	1	1	1	1	0	1	0	1	0
17	Left	1	1	1	1	1	1	1	0	1	0
17	Right	1	1	1	1	1	1	1	0	0	0
Altruism	unknown	1	1	1	1	1	1	1	0	1	0
Johnston Stir	unknown	1	1	1	1	1	1	1	0	0	0
Lockwood	unknown	1	1	1	1	1	1	1	0	0	0
Modun	unknown	1	1	1	1	1	1	0	0	0	0
Stoute seraphina	unknown	1	1	1	1	1	1	1	0	1	0
Coral Bee	unknown	1	1	1	0	1	1	0	0	0	0
Genius Beast	unknown	1	1	1	1	1	1	0	0	1	0
Johnston Cosquila	unknown	1	1	1	1	1	1	0	0	0	0
Johnston Jalingo	unknown	1	1	1	0	1	1	0	1	1	0
Khotan	unknown	1	1	1	1	1	1	1	0	0	0
Latch on the Blue	unknown	1	1	1	1	1	1	0	0	0	0
Michelton	unknown	1	1	1	1	1	0	1	0	0	0
Revolutionist	unknown	1	1	1	0	1	1	1	0	0	0
Walter	unknown	1	1	1	0	1	1	1	0	0	0
Amber Isle	unknown	1	1	1	1	1	1	0	0	0	0
Bergamot Orange	unknown	1	1	1	1	1	1	0	0	0	0
Camlann	unknown	1	1	1	1	1	0	0	0	0	0

Table 7: 15mm proximal phalanx

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J
1	Left	1	1	1	1	1	1	1	0	0	1
1	Right	1	1	1	1	1	1	1	0	0	1
2	Left	1	1	1	1	0	0	1	0	0	1
2	Right	1	1	1	1	0	1	0	0	0	1
3	Left	1	1	1	1	1	1	0	0	0	1
3	Right	1	1	1	1	1	1	0	0	0	1
4	Left	1	1	1	1	1	0	0	0	0	1
4	Right	1	1	1	1	1	1	1	0	0	1
5	Left	1	1	1	1	1	1	0	0	0	1
5	Right	1	1	1	1	1	1	0	0	0	1
6	Left	1	1	1	1	1	1	1	0	0	1
6	Right	1	1	1	1	1	1	1	0	0	1
7	Left	1	1	1	1	1	1	0	0	0	1
7	Right	1	1	1	1	1	1	1	0	0	1
9	Left	1	1	1	1	1	1	1	0	0	1
9	Right	1	1	1	1	1	1	1	0	0	1
10	Left	1	1	1	1	1	1	0	0	0	1
10	Right	1	1	1	1	1	1	0	0	0	1
14	Left	1	1	1	1	1	1	1	0	0	1
14	Right	1	1	1	1	1	1	1	0	0	1
16	Left	1	1	1	1	1	1	1	0	1	1
16	Right	1	1	1	1	1	1	1	0	0	1
17	Left	1	1	1	1	1	1	1	0	0	1
17	Right	1	1	1	1	1	1	1	0	0	1
Altruism	unknown	1	1	1	1	1	1	1	0	0	1
Johnston Stir	unknown	1	1	1	1	1	1	1	0	0	1
Lockwood	unknown	1	1	1	1	1	1	1	0	0	1
Modun	unknown	1	1	1	1	1	1	1	0	0	1
Stoute seraphina	unknown	1	1	1	1	1	1	1	0	0	1
Coral Bee	unknown	1	1	1	0	1	1	0	0	0	0
Genius Beast	unknown	1	1	1	1	1	1	0	0	0	1
Johnston Cosquila	unknown	1	1	1	1	1	1	0	0	0	1
Johnston Jalingo	unknown	1	1	1	0	1	1	0	0	0	0
Khotan	unknown	1	1	1	1	1	1	1	0	0	1
Latch on the Blue	unknown	1	1	1	1	1	1	0	0	0	1
Michelton	unknown	1	1	1	0	1	1	0	0	0	0
Revolutionist	unknown	1	1	1	1	1	1	0	0	0	0
Walter	unknown	1	1	1	0	1	1	1	0	0	0
Amber Isle	unknown	1	1	1	1	1	1	0	0	0	0
Bergamot Orange	unknown	1	1	1	0	1	1	0	0	0	0
Camlann	unknown	1	1	1	1	1	1	1	0	0	1

Table 8: 20mm proximal phalanx

Horse	Limb	*A	*B	*C	*D	*E	*F	*G	*H	*I	*J
1	Left	1	1	1	1	1	1	1	0	0	1
1	Right	1	1	1	1	1	1	0	0	0	1
2	Left	1	1	1	1	1	1	0	0	0	1
2	Right	1	1	1	1	1	1	0	0	0	1
3	Left	1	1	1	1	1	1	0	0	0	1
3	Right	1	1	1	1	1	1	0	0	0	1
4	Left	1	1	1	1	1	1	0	0	0	1
4	Right	1	1	1	1	1	1	0	0	0	1
5	Left	1	1	1	1	1	1	0	0	0	1
5	Right	1	1	1	1	1	1	0	0	0	1
6	Left	1	1	1	1	1	1	0	0	0	1
6	Right	1	1	1	1	1	1	0	0	0	1
7	Left	1	1	1	1	1	1	0	0	0	1
7	Right	1	1	1	1	1	1	0	0	0	1
9	Left	1	1	1	1	1	1	0	0	0	1
9	Right	1	1	1	1	1	1	0	0	0	1
10	Left	1	1	1	1	1	1	0	0	0	1
10	Right	1	1	1	1	1	1	0	0	0	1
14	Left	1	1	1	1	1	1	0	0	0	1
14	Right	1	1	1	1	1	1	0	0	0	1
16	Left	1	1	1	1	1	1	0	0	0	1
16	Right	1	1	1	1	1	1	0	0	0	1
17	Left	1	1	1	1	1	1	0	0	0	1
17	Right	1	1	1	1	1	1	0	0	0	1
Altruism	unknown	1	1	1	1	1	1	0	1	0	1
Johnston Stir	unknown	1	1	1	1	1	1	0	1	0	1
Lockwood	unknown	1	1	1	1	1	1	0	1	1	1
Modun	unknown	1	1	1	1	1	1	0	1	1	1
Stoute seraphina	unknown	1	1	1	1	1	1	0	1	1	1
Coral Bee	unknown	1	1	1	0	1	1	0	0	0	0
Genius Beast	unknown	1	1	1	1	1	1	0	0	0	0
Johnston Cosquila	unknown	1	1	1	1	1	1	0	0	0	0
Johnston Jalingo	unknown	1	1	1	0	1	1	1	0	0	0
Khotan	unknown	1	1	1	1	1	1	1	0	0	1
Latch on the Blue	unknown	1	1	1	1	1	1	0	0	0	1
Michelton	unknown	1	1	1	1	1	1	0	0	0	1
Revolutionist	unknown	1	1	1	1	1	1	0	0	0	0
Walter	unknown	1	1	1	1	1	1	1	1	1	1
Amber Isle	unknown	1	1	1	1	1	1	0	0	0	1
Bergamot Orange	unknown	1	1	1	0	1	1	0	0	0	0
Camlann	unknown	1	1	1	1	1	1	1	0	0	1

Legend table 4 to 8

*A = Denser area at the medial side
*B = Denser area at the lateral side
*C = Denser area at the dorsal side
*D = Less dense in the middle of the proximal side
*E = Less dense area at the medioproximal side
*F = Less dense area at the lateroproximal side
*G = Less dense area in the middle of the dorsal side
*H = Less dense area at the mediadorsal side
*I = Less dense area at the laterodorsal side
*J = Homogenous less dense area in the middle of the bone

Table 9: 5mm Proximal sesamoid bones – Transverse plane

Transverse plane						
Horse	Limb	PSB	*A	*B	*C	*D
1	Left	medial	1	1	1	1
1	Left	lateral	1	1	0	1
1	Right	medial	1	1	1	1
1	Right	lateral	1	1	0	1
2	Left	medial	1	1	1	1
2	Left	lateral	1	1	0	1
2	Right	medial	1	1	1	1
2	Right	lateral	1	1	1	1
3	Left	medial	1	1	1	1
3	Left	lateral	1	1	0	1
3	Right	medial	1	1	1	1
3	Right	lateral	1	1	0	1
4	Left	medial	1	1	0	1
4	Left	lateral	1	1	0	1
4	Right	medial	1	1	1	1
4	Right	lateral	1	1	0	1
5	Left	medial	1	1	0	1
5	Left	lateral	1	1	0	1
5	Right	medial	1	1	1	1
5	Right	lateral	1	1	0	1
6	Left	medial	1	1	1	1
6	Left	lateral	1	1	1	1
6	Right	medial	1	1	1	1
6	Right	lateral	1	1	1	1
7	Left	medial	1	0	1	1
7	Left	lateral	0	1	1	1
7	Right	medial	1	0	1	1
7	Right	lateral	0	1	1	1
9	Left	medial	1	1	1	1
9	Left	lateral	1	1	0	1
9	Right	medial	1	1	1	1
9	Right	lateral	1	1	0	1
10	Left	medial	1	0	1	1
10	Left	lateral	0	1	1	1
10	Right	medial	1	0	0	1
10	Right	lateral	1	0	0	1
14	Left	medial	1	1	1	1
14	Left	lateral	1	1	1	1
14	Right	medial	1	1	1	1
14	Right	lateral	1	1	1	1
16	Left	medial	1	1	1	1
16	Left	lateral	1	1	1	1
16	Right	medial	1	1	1	1
16	Right	lateral	1	1	1	1
17	Left	medial	1	0	1	1
17	Left	lateral	0	1	0	1
17	Right	medial	1	0	1	1
17	Right	lateral	1	0	0	1
Altruism	unknown	medial	1	1	0	1
Altruism	unknown	lateral	1	1	0	1
Amber Isle	unknown	medial	1	0	0	1
Amber Isle	unknown	lateral	0	1	0	1
Chapparachick	unknown	medial	1	1	1	1
Chapparachick	unknown	lateral	1	1	1	1
Harjas	unknown	medial	1	1	0	0
Harjas	unknown	lateral	1	1	0	1
Magic Mystery	unknown	medial	1	1	0	1
Magic Mystery	unknown	lateral	1	1	0	1
Johnston Stir	unknown	medial	1	1	1	1
Johnston Stir	unknown	lateral	1	1	1	1
Khotan	unknown	medial	1	1	0	1
Khotan	unknown	lateral	1	1	0	1
Sadaara	unknown	medial	1	1	1	1
Sadaara	unknown	lateral	1	1	0	1
Titled Lady	unknown	medial	1	1	1	1
Titled Lady	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	medial	1	1	1	1
Modun	unknown	lateral	1	0	1	1
Modun	unknown	medial	1	1	0	1
Lockwood	unknown	lateral	1	1	0	0
Lockwood	unknown	medial	1	1	0	0

Table 10: 5mm Proximal sesamoid bones – Dorsal plane

Dorsal plane							
Horse	Limb	PSB	*E	*F	*G	*H	*I
1	Left	medial	1	1	0	1	1
1	Left	lateral	1	1	0	1	1
1	Right	medial	1	1	0	1	1
1	Right	lateral	1	1	0	1	1
2	Left	medial	1	1	0	1	1
2	Left	lateral	1	1	0	1	1
2	Right	medial	1	1	0	1	1
2	Right	lateral	1	1	0	1	1
3	Left	medial	1	1	0	1	0
3	Left	lateral	1	1	0	1	0
3	Right	medial	1	1	0	1	0
3	Right	lateral	1	1	0	1	1
4	Left	medial	1	1	0	1	0
4	Left	lateral	1	1	0	1	0
4	Right	medial	1	1	0	1	0
4	Right	lateral	1	1	0	1	1
5	Left	medial	1	1	0	1	1
5	Left	lateral	1	1	0	1	1
5	Right	medial	1	1	0	1	0
5	Right	lateral	1	1	0	1	1
6	Left	medial	1	1	0	1	0
6	Left	lateral	1	1	0	1	1
6	Right	medial	1	1	0	1	1
6	Right	lateral	1	1	0	1	1
7	Left	medial	1	1	0	1	1
7	Left	lateral	1	1	0	1	1
7	Right	medial	1	1	0	1	1
7	Right	lateral	1	1	0	1	1
9	Left	medial	0	0	0	1	1
9	Left	lateral	0	0	0	1	1
9	Right	medial	0	0	0	1	1
9	Right	lateral	0	0	0	1	1
10	Left	medial	1	1	0	1	1
10	Left	lateral	1	1	0	1	1
10	Right	medial	1	1	0	1	1
10	Right	lateral	1	1	0	1	1
14	Left	medial	1	1	0	1	1
14	Left	lateral	1	1	0	1	1
14	Right	medial	1	1	0	1	1
14	Right	lateral	1	1	0	1	1
16	Left	medial	1	1	0	1	1
16	Left	lateral	1	1	0	1	1
16	Right	medial	1	1	0	1	1
16	Right	lateral	1	1	0	1	1
17	Left	medial	1	1	0	0	1
17	Left	lateral	1	1	0	0	1
17	Right	medial	1	1	0	0	1
17	Right	lateral	1	1	0	0	1
Altruism	unknown	medial	1	1	0	0	0
Altruism	unknown	lateral	1	0	1	0	0
Amber Isle	unknown	medial	1	1	0	1	0
Amber Isle	unknown	lateral	1	1	0	1	0
Chapparachick	unknown	medial	0	1	0	1	1
Chapparachick	unknown	lateral	0	1	0	1	1
Harjas	unknown	medial	1	1	1	0	0
Harjas	unknown	lateral	1	1	1	0	0
Magic Mystery	unknown	medial	1	1	0	1	0
Magic Mystery	unknown	lateral	1	1	0	1	1
Johnston Stir	unknown	medial	1	1	0	1	0
Johnston Stir	unknown	lateral	1	1	0	1	1
Khotan	unknown	medial	1	1	0	1	1
Khotan	unknown	lateral	1	1	0	1	1
Sadaara	unknown	medial	1	1	0	1	0
Sadaara	unknown	lateral	1	1	0	1	1
Titled Lady	unknown	medial	1	1	0	1	0
Titled Lady	unknown	lateral	1	1	0	1	1
Stoute Seraphina	unknown	lateral	1	1	1	1	1
Stoute Seraphina	unknown	medial	1	1	1	1	1
Modun	unknown	lateral	1	1	0	0	0
Modun	unknown	medial	1	1	0	0	0
Lockwood	unknown	lateral	0	1	1	1	0
Lockwood	unknown	medial	0	1	1	1	0

Table 11: 10mm Proximal sesamoid bones – Transverse plane

Transverse plane						
Horse	Limb	PSB	*A	*B	*C	*D
1	Left	medial	1	0	1	1
1	Left	lateral	0	1	0	1
1	Right	medial	1	0	1	1
1	Right	lateral	1	1	1	1
2	Left	medial	1	1	0	1
2	Left	lateral	1	1	0	1
2	Right	medial	1	1	1	1
2	Right	lateral	1	1	1	1
3	Left	medial	1	0	1	1
3	Left	lateral	0	1	0	1
3	Right	medial	1	0	1	1
3	Right	lateral	0	1	0	1
4	Left	medial	1	1	0	1
4	Left	lateral	1	1	0	1
4	Right	medial	1	1	0	1
4	Right	lateral	1	1	1	1
5	Left	medial	1	1	0	1
5	Left	lateral	1	1	0	1
5	Right	medial	1	1	0	1
5	Right	lateral	1	1	0	1
6	Left	medial	1	1	1	1
6	Left	lateral	1	1	1	1
6	Right	medial	1	1	0	1
6	Right	lateral	1	1	1	1
7	Left	medial	1	0	1	1
7	Left	lateral	0	1	0	1
7	Right	medial	1	1	0	1
7	Right	lateral	1	1	1	1
9	Left	medial	1	1	1	1
9	Left	lateral	1	1	0	1
9	Right	medial	1	1	1	1
9	Right	lateral	1	1	0	1
10	Left	medial	1	0	1	1
10	Left	lateral	0	1	0	1
10	Right	medial	1	0	0	1
10	Right	lateral	0	1	0	1
14	Left	medial	1	1	0	1
14	Left	lateral	0	1	0	1
14	Right	medial	1	0	0	1
14	Right	lateral	0	1	0	1
16	Left	medial	1	1	1	1
16	Left	lateral	0	1	0	1
16	Right	medial	1	1	1	1
16	Right	lateral	1	1	0	1
17	Left	medial	1	0	0	1
17	Left	lateral	0	1	0	1
17	Right	medial	1	1	0	1
17	Right	lateral	0	1	0	1
Altruism	unknown	medial	1	1	0	1
Altruism	unknown	lateral	1	1	0	1
Amber Isle	unknown	medial	1	0	0	1
Amber Isle	unknown	lateral	0	1	0	1
Chapparachick	unknown	medial	1	1	0	1
Chapparachick	unknown	lateral	1	1	0	1
Harjas	unknown	medial	1	1	0	1
Harjas	unknown	lateral	1	1	0	0
Magic Mystery	unknown	medial	1	1	0	1
Magic Mystery	unknown	lateral	1	1	1	1
Johnston Stir	unknown	medial	1	1	0	1
Johnston Stir	unknown	lateral	1	1	1	1
Khotan	unknown	medial	1	0	0	1
Khotan	unknown	lateral	1	0	0	1
Sadaara	unknown	medial	1	1	1	1
Sadaara	unknown	lateral	0	1	0	1
Titled Lady	unknown	medial	1	1	1	1
Titled Lady	unknown	lateral	0	1	1	1
Stoute Seraphina	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	medial	1	1	0	1
Modun	unknown	lateral	1	0	1	1
Modun	unknown	medial	0	1	0	1
Lockwood	unknown	lateral	1	1	0	1
Lockwood	unknown	medial	1	1	0	1

Table 12: 10mm Proximal sesamoid bones – Dorsal plane

Dorsal plane							
Horse	Limb	PSB	*E	*F	*G	*H	*I
1	Left	medial	1	1	1	1	1
1	Left	lateral	1	1	1	1	1
1	Right	medial	1	1	0	1	1
1	Right	lateral	1	1	0	1	1
2	Left	medial	1	1	0	1	1
2	Left	lateral	1	1	0	1	1
2	Right	medial	1	1	0	1	1
2	Right	lateral	1	1	0	1	1
3	Left	medial	1	1	0	1	0
3	Left	lateral	1	1	0	1	0
3	Right	medial	1	1	0	1	0
3	Right	lateral	1	1	0	1	0
4	Left	medial	1	1	0	1	0
4	Left	lateral	1	1	0	1	0
4	Right	medial	1	1	0	1	0
4	Right	lateral	1	1	0	1	1
5	Left	medial	1	1	0	1	0
5	Left	lateral	1	1	0	1	0
5	Right	medial	1	1	0	1	0
5	Right	lateral	1	1	0	1	0
6	Left	medial	1	0	1	1	0
6	Left	lateral	1	0	1	1	1
6	Right	medial	1	0	1	1	0
6	Right	lateral	1	0	1	1	1
7	Left	medial	1	0	1	1	0
7	Left	lateral	1	0	1	1	1
7	Right	medial	1	0	1	1	0
7	Right	lateral	1	0	1	1	1
9	Left	medial	0	1	0	1	1
9	Left	lateral	0	1	0	1	1
9	Right	medial	0	1	0	1	1
9	Right	lateral	0	1	0	1	1
10	Left	medial	1	1	0	1	1
10	Left	lateral	1	1	0	1	1
10	Right	medial	1	1	0	1	1
10	Right	lateral	1	1	0	1	1
14	Left	medial	1	1	0	1	1
14	Left	lateral	1	1	0	1	1
14	Right	medial	1	1	0	1	1
14	Right	lateral	1	1	0	1	1
16	Left	medial	1	1	0	1	1
16	Left	lateral	1	1	0	1	1
16	Right	medial	1	1	0	1	1
16	Right	lateral	1	1	0	1	1
17	Left	medial	1	1	0	1	0
17	Left	lateral	1	1	0	1	0
17	Right	medial	1	1	0	1	0
17	Right	lateral	1	1	0	1	0
Altruism	unknown	medial	1	0	1	1	0
Altruism	unknown	lateral	1	0	1	1	0
Amber Isle	unknown	medial	1	1	0	1	1
Amber Isle	unknown	lateral	1	1	0	1	1
Chapparachick	unknown	medial	1	0	1	1	1
Chapparachick	unknown	lateral	1	0	1	1	1
Harjas	unknown	medial	1	0	1	1	1
Harjas	unknown	lateral	1	0	1	1	1
Magic Mystery	unknown	medial	1	0	1	1	1
Magic Mystery	unknown	lateral	1	0	1	1	1
Johnston Stir	unknown	medial	1	0	1	1	1
Johnston Stir	unknown	lateral	1	0	1	1	1
Khotan	unknown	medial	1	0	1	1	1
Khotan	unknown	lateral	1	0	1	1	1
Sadaara	unknown	medial	1	0	1	1	1
Sadaara	unknown	lateral	1	0	1	1	1
Titled Lady	unknown	medial	1	0	1	1	1
Titled Lady	unknown	lateral	1	0	1	1	1
Stoute Seraphina	unknown	lateral	1	0	1	1	1
Stoute Seraphina	unknown	medial	1	0	1	1	1
Modun	unknown	lateral	1	1	1	1	1
Modun	unknown	medial	1	1	1	1	1
Lockwood	unknown	lateral	0	0	1	1	0
Lockwood	unknown	medial	0	0	1	1	0

Table 13: 15mm Proximal sesamoid bones – Transverse plane

Transverse plane						
Horse	Limb	PSB	*A	*B	*C	*D
1	Left	medial	1	0	0	1
1	Left	lateral	1	1	0	1
1	Right	medial	1	1	0	1
1	Right	lateral	1	1	0	1
2	Left	medial	1	1	0	1
2	Left	lateral	1	1	0	1
2	Right	medial	1	1	0	1
2	Right	lateral	1	1	0	1
3	Left	medial	1	1	1	1
3	Left	lateral	1	1	1	1
3	Right	medial	1	1	1	1
3	Right	lateral	1	1	1	1
4	Left	medial	1	1	0	1
4	Left	lateral	1	1	0	1
4	Right	medial	1	1	0	1
4	Right	lateral	1	1	0	1
5	Left	medial	1	1	0	1
5	Left	lateral	1	1	0	1
5	Right	medial	1	1	0	1
5	Right	lateral	1	1	0	1
6	Left	medial	1	1	1	1
6	Left	lateral	1	1	0	1
6	Right	medial	1	1	0	1
6	Right	lateral	1	1	0	1
7	Left	medial	1	1	1	1
7	Left	lateral	1	1	0	1
7	Right	medial	1	1	0	1
7	Right	lateral	1	1	0	1
9	Left	medial	1	1	0	1
9	Left	lateral	1	1	0	1
9	Right	medial	1	1	0	1
9	Right	lateral	1	1	0	1
10	Left	medial	1	1	0	1
10	Left	lateral	1	1	0	1
10	Right	medial	1	1	0	1
10	Right	lateral	1	1	0	1
14	Left	medial	1	1	0	1
14	Left	lateral	0	1	0	1
14	Right	medial	0	1	0	1
14	Right	lateral	0	1	0	1
16	Left	medial	1	1	1	1
16	Left	lateral	1	1	0	1
16	Right	medial	1	1	0	1
16	Right	lateral	1	1	0	1
17	Left	medial	1	1	0	1
17	Left	lateral	1	1	0	1
17	Right	medial	1	1	0	1
17	Right	lateral	1	1	0	1
Altruism	unknown	medial	1	1	0	1
Altruism	unknown	lateral	1	1	0	1
Amber Isle	unknown	medial	1	1	0	1
Amber Isle	unknown	lateral	1	1	0	1
Chapparachick	unknown	medial	1	1	0	1
Chapparachick	unknown	lateral	1	1	0	1
Harjas	unknown	medial	1	1	0	1
Harjas	unknown	lateral	1	1	0	1
Magic Mystery	unknown	medial	1	1	0	1
Magic Mystery	unknown	lateral	1	1	0	1
Johnston Stir	unknown	medial	1	1	0	1
Johnston Stir	unknown	lateral	1	1	0	1
Khotan	unknown	medial	1	1	0	1
Khotan	unknown	lateral	1	1	0	1
Sadaara	unknown	medial	1	1	0	1
Sadaara	unknown	lateral	1	1	0	1
Titled Lady	unknown	medial	1	1	0	1
Titled Lady	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	medial	1	1	0	1
Modun	unknown	lateral	1	1	0	1
Modun	unknown	medial	0	1	0	1
Lockwood	unknown	lateral	1	1	0	1
Lockwood	unknown	medial	1	1	0	0

Table 14: 15mm Proximal sesamoid bones – Dorsal plane

Dorsal plane							
Horse	Limb	PSB	*E	*F	*G	*H	*I
1	Left	medial	1	0	1	1	0
1	Left	lateral	1	0	1	1	0
1	Right	medial	1	0	1	1	0
1	Right	lateral	1	0	1	1	0
2	Left	medial	1	1	0	1	1
2	Left	lateral	1	1	0	1	1
2	Right	medial	1	1	0	1	1
2	Right	lateral	1	1	0	1	1
3	Left	medial	1	1	0	1	0
3	Left	lateral	1	1	0	1	0
3	Right	medial	1	1	0	1	0
3	Right	lateral	1	1	0	1	0
4	Left	medial	1	1	0	1	0
4	Left	lateral	1	1	0	1	0
4	Right	medial	1	1	0	1	0
4	Right	lateral	1	1	0	1	0
5	Left	medial	1	1	0	1	0
5	Left	lateral	1	1	0	1	0
5	Right	medial	1	1	0	1	0
5	Right	lateral	1	1	0	1	0
6	Left	medial	1	0	1	1	1
6	Left	lateral	1	0	1	1	1
6	Right	medial	1	0	1	1	1
6	Right	lateral	1	0	1	1	1
7	Left	medial	1	1	0	1	0
7	Left	lateral	1	0	1	1	0
7	Right	medial	1	0	1	1	0
7	Right	lateral	1	0	1	1	0
9	Left	medial	1	0	1	1	1
9	Left	lateral	1	0	1	1	1
9	Right	medial	1	0	1	1	1
9	Right	lateral	1	0	1	1	1
10	Left	medial	0	0	1	1	1
10	Left	lateral	1	1	0	1	1
10	Right	medial	1	1	0	1	1
10	Right	lateral	1	1	0	1	1
14	Left	medial	1	0	1	1	1
14	Left	lateral	1	1	0	1	1
14	Right	medial	1	1	0	1	1
14	Right	lateral	1	1	0	1	1
16	Left	medial	0	0	1	1	1
16	Left	lateral	1	1	0	1	1
16	Right	medial	0	0	1	1	1
16	Right	lateral	1	1	0	1	1
17	Left	medial	1	1	0	1	0
17	Left	lateral	1	1	0	1	0
17	Right	medial	1	1	0	1	0
17	Right	lateral	1	1	0	1	0
Altruism	unknown	medial	1	0	1	1	0
Altruism	unknown	lateral	1	0	1	1	0
Amber Isle	unknown	medial	1	0	1	1	0
Amber Isle	unknown	lateral	1	0	1	1	0
Chapparachick	unknown	medial	1	0	1	1	1
Chapparachick	unknown	lateral	1	0	1	1	1
Harjas	unknown	medial	1	0	1	1	1
Harjas	unknown	lateral	1	0	1	1	1
Magic Mystery	unknown	medial	1	0	1	1	0
Magic Mystery	unknown	lateral	1	0	1	1	0
Johnston Stir	unknown	medial	1	0	1	1	1
Johnston Stir	unknown	lateral	1	0	1	1	1
Khotan	unknown	medial	1	0	1	1	1
Khotan	unknown	lateral	1	0	1	1	1
Sadaara	unknown	medial	1	0	1	1	1
Sadaara	unknown	lateral	1	0	1	1	1
Titled Lady	unknown	medial	1	0	1	1	1
Titled Lady	unknown	lateral	1	0	1	1	1
Stoute Seraphina	unknown	lateral	1	1	0	1	1
Stoute Seraphina	unknown	medial	0	1	0	0	1
Modun	unknown	lateral	1	1	1	1	1
Modun	unknown	medial	1	1	1	1	1
Lockwood	unknown	lateral	1	0	1	1	1
Lockwood	unknown	medial	1	0	1	1	1

Table 15: 20mm Proximal sesamoid bones – Transverse plane

Transverse plane						
Horse	**Limb**	**PSB**	***A**	***B**	***C**	***D**
1	Left	medial	1	1	0	1
1	Left	lateral	1	1	0	1
1	Right	medial	1	0	0	1
1	Right	lateral	1	1	0	1
2	Left	medial	1	1	0	1
2	Left	lateral	0	1	0	1
2	Right	medial	1	1	0	1
2	Right	lateral	1	1	0	1
3	Left	medial	1	1	0	1
3	Left	lateral	1	1	0	1
3	Right	medial	1	1	1	1
3	Right	lateral	1	1	0	1
4	Left	medial	1	1	0	1
4	Left	lateral	0	0	0	1
4	Right	medial	0	0	0	1
4	Right	lateral	0	0	0	1
5	Left	medial	1	0	0	1
5	Left	lateral	0	1	0	1
5	Right	medial	1	1	0	1
5	Right	lateral	1	1	0	1
6	Left	medial	1	1	0	1
6	Left	lateral	1	1	0	1
6	Right	medial	1	1	0	1
6	Right	lateral	1	1	0	1
7	Left	medial	1	1	0	1
7	Left	lateral	0	1	0	1
7	Right	medial	1	1	0	1
7	Right	lateral	0	1	0	1
9	Left	medial	1	1	1	1
9	Left	lateral	1	1	0	1
9	Right	medial	1	1	0	1
9	Right	lateral	1	1	0	1
10	Left	medial	1	1	1	1
10	Left	lateral	1	1	1	1
10	Right	medial	1	1	0	1
10	Right	lateral	1	1	0	1
14	Left	medial	1	1	0	1
14	Left	lateral	0	1	0	1
14	Right	medial	1	0	0	1
14	Right	lateral	0	1	0	1
16	Left	medial	1	1	0	1
16	Left	lateral	1	1	0	1
16	Right	medial	1	1	0	1
16	Right	lateral	1	1	0	1
17	Left	medial	1	1	0	1
17	Left	lateral	1	1	0	1
17	Right	medial	1	1	0	1
17	Right	lateral	1	1	0	1
Altruism	unknown	medial	0	1	0	1
Altruism	unknown	lateral	1	1	0	1
Amber Isle	unknown	medial	1	1	0	1
Amber Isle	unknown	lateral	1	1	0	1
Chapparachick	unknown	medial	1	1	0	1
Chapparachick	unknown	lateral	1	1	0	1
Harjas	unknown	medial	1	1	0	1
Harjas	unknown	lateral	1	1	0	1
Magic Mystery	unknown	medial	1	1	0	1
Magic Mystery	unknown	lateral	1	1	0	1
Johnston Stir	unknown	medial	1	1	0	1
Johnston Stir	unknown	lateral	1	1	0	1
Khotan	unknown	medial	1	1	1	0
Khotan	unknown	lateral	1	1	0	1
Sadaara	unknown	medial	1	1	0	1
Sadaara	unknown	lateral	1	1	0	1
Titled Lady	unknown	medial	1	1	0	1
Titled Lady	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	medial	1	1	0	1
Modun	unknown	lateral	1	1	0	1
Modun	unknown	medial	0	1	0	1
Lockwood	unknown	lateral	1	1	0	1
Lockwood	unknown	medial	1	1	0	1

Table 16: 25mm Proximal sesamoid bones – Transverse plane

Transverse plane						
Horse	Limb	PSB	*A	*B	*C	*D
1	Left	medial	1	0	0	1
1	Left	lateral	0	1	0	1
1	Right	medial	1	0	0	0
1	Right	lateral	0	1	0	1
2	Left	medial	1	1	1	1
2	Left	lateral	0	1	0	1
2	Right	medial	1	0	0	1
2	Right	lateral	0	1	0	1
3	Left	medial	1	1	0	1
3	Left	lateral	1	1	0	1
3	Right	medial	1	0	0	1
3	Right	lateral	0	1	0	1
4	Left	medial	0	0	0	0
4	Left	lateral	0	0	0	1
4	Right	medial	0	0	0	0
4	Right	lateral	0	0	0	0
5	Left	medial	1	0	0	1
5	Left	lateral	0	0	0	1
5	Right	medial	1	0	0	1
5	Right	lateral	0	1	0	1
6	Left	medial	1	1	0	1
6	Left	lateral	1	1	0	1
6	Right	medial	1	1	0	1
6	Right	lateral	1	1	0	1
7	Left	medial	1	0	0	1
7	Left	lateral	0	1	0	1
7	Right	medial	1	0	0	0
7	Right	lateral	1	0	0	0
9	Left	medial	1	1	0	0
9	Left	lateral	1	1	0	0
9	Right	medial	1	1	0	1
9	Right	lateral	1	1	0	1
10	Left	medial	1	1	0	0
10	Left	lateral	1	1	0	0
10	Right	medial	1	1	0	0
10	Right	lateral	1	1	0	0
14	Left	medial	1	0	0	1
14	Left	lateral	0	1	0	1
14	Right	medial	1	0	0	1
14	Right	lateral	0	1	0	1
16	Left	medial	1	1	0	1
16	Left	lateral	0	1	0	1
16	Right	medial	1	1	0	1
16	Right	lateral	1	1	0	1
17	Left	medial	1	1	0	1
17	Left	lateral	1	1	0	1
17	Right	medial	1	1	0	1
17	Right	lateral	1	1	0	1
Altruism	unknown	medial	1	1	0	1
Altruism	unknown	lateral	1	1	0	1
Amber Isle	unknown	medial	1	1	0	1
Amber Isle	unknown	lateral	1	1	0	0
Chapparachick	unknown	medial	0	1	0	0
Chapparachick	unknown	lateral	1	1	0	0
Harjas	unknown	medial	1	1	0	0
Harjas	unknown	lateral	1	1	0	0
Magic Mystery	unknown	medial	1	1	0	0
Magic Mystery	unknown	lateral	1	1	0	0
Johnston Stir	unknown	medial	1	1	0	0
Johnston Stir	unknown	lateral	1	1	0	0
Khotan	unknown	medial	1	1	0	1
Khotan	unknown	lateral	1	1	0	1
Sadaara	unknown	medial	1	1	0	1
Sadaara	unknown	lateral	1	1	0	1
Titled Lady	unknown	medial	1	1	0	1
Titled Lady	unknown	lateral	1	1	0	1
Stoute Seraphina	unknown	lateral	1	1	0	0
Stoute Seraphina	unknown	medial	1	1	0	0
Modun	unknown	lateral	1	1	0	1
Modun	unknown	medial	1	1	0	1
Lockwood	unknown	lateral	0	1	0	0
Lockwood	unknown	medial	1	1	0	0

Legend table 8 to 16

*A = Denser area medial side
*B = Denser area lateral side
*C = Denser area palmar side
*D = Line of less density from the proximal side, which faces the third metacarpal bone, to the distopalmar side of the bones.
*E = lower density at the top
*F = Lower density where bones facing each other
*G = Higher density where bones facing each other
*H = Higher density at the medial respectively lateral side
*I = Higher density at the bottom of the bone