1. Case “Bxxxxx” – carpal joint.

1.1. Extreme changes in left carpal joint with two fractures.
There were several RAD images sent in the original document on pages 1...5. The best shot is on original page 5 with the skyline view (Fig. 1).

Fig. 1. RAD image Skyline view

The picture clearly shows two fractures (shown by arrows). According to our measurements, the contrast of cracks on the image at Fig. 1 is K=0.45, which makes it possible to visually separate the fragments from the main bone. On the original images on pages 1...4 two fragments are not visible at the same time. The contrast of cracks is K=0.1...0.25, which is close to the limit value of visual observation K=0.05 (Weber-Fechner law). Cracks are observable badly with possible errors. The worst image is shown on original page 1 (Fig. 2), where the fragments are almost invisible.

Fig. 2. RAD image DP view (original page 1)

To compare the capabilities of radiography and tomosynthesis, we took a scan you made in the direction of the worst image at Fig. 2. Layers 100, 65 and 61 of this scan are presented on page 8-9 (Fig. 3).

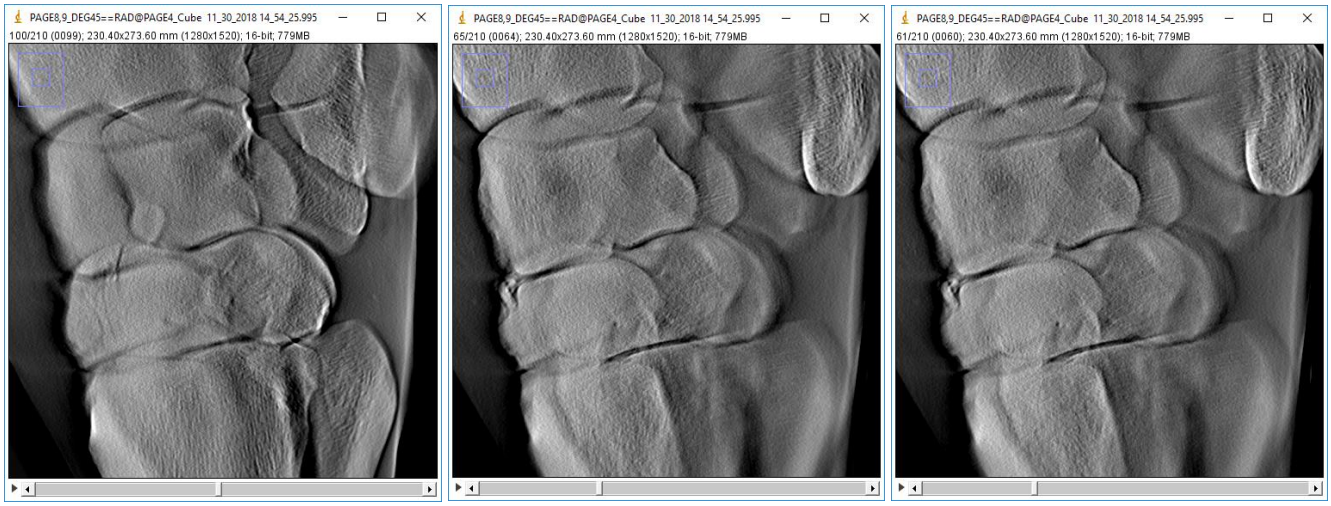

Fig. 3. Slices 100, 65, 61 (original pages 8-9)

A more detailed analysis of layers 45...80 (Fig. 4) makes it possible to see on the images the destruction of the bone, corresponding to the right fragment on the image at Fig. 1.

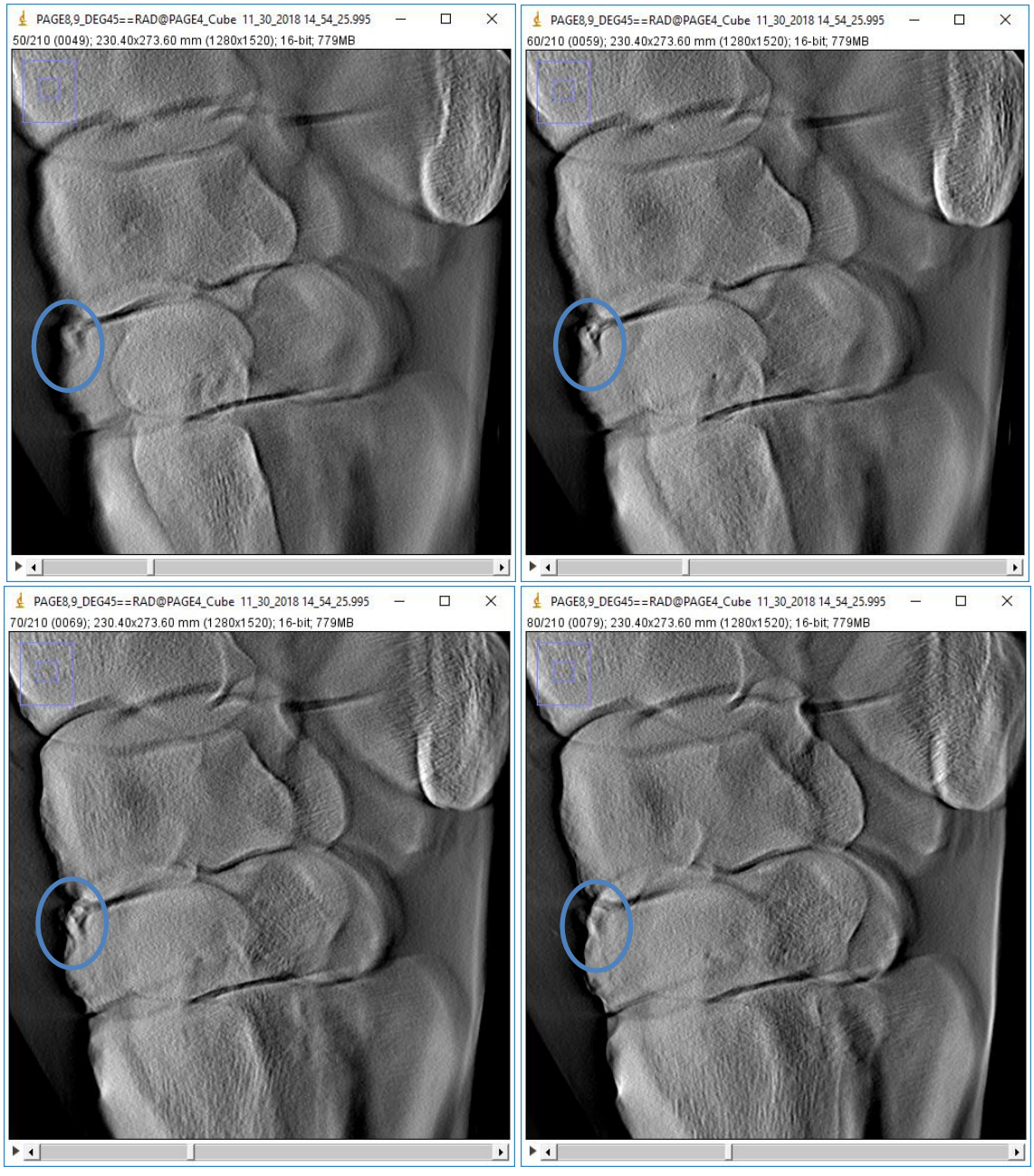

Fig. 4. Slices 45...80

In the images of layers 45...80, three fragments of bone are well distinguished, and not one, as on the Fig. 1. The total size of the fragments in depth is about 20 mm, which is confirmed by the Fig. 1 and cannot be measured from the Fig. 2.

On layers 75...110, the left fragment in the image at Fig. 1 is visible. The size of the fragment in depth is about 20 mm, which is confirmed by the Fig. 1 and cannot be measured from the image at Fig. 2. Instead of one crack in the image at Fig. 1, tomosynthesis on layer 100 allows you to simultaneously see 3 cracks in the bone (Fig. 5).

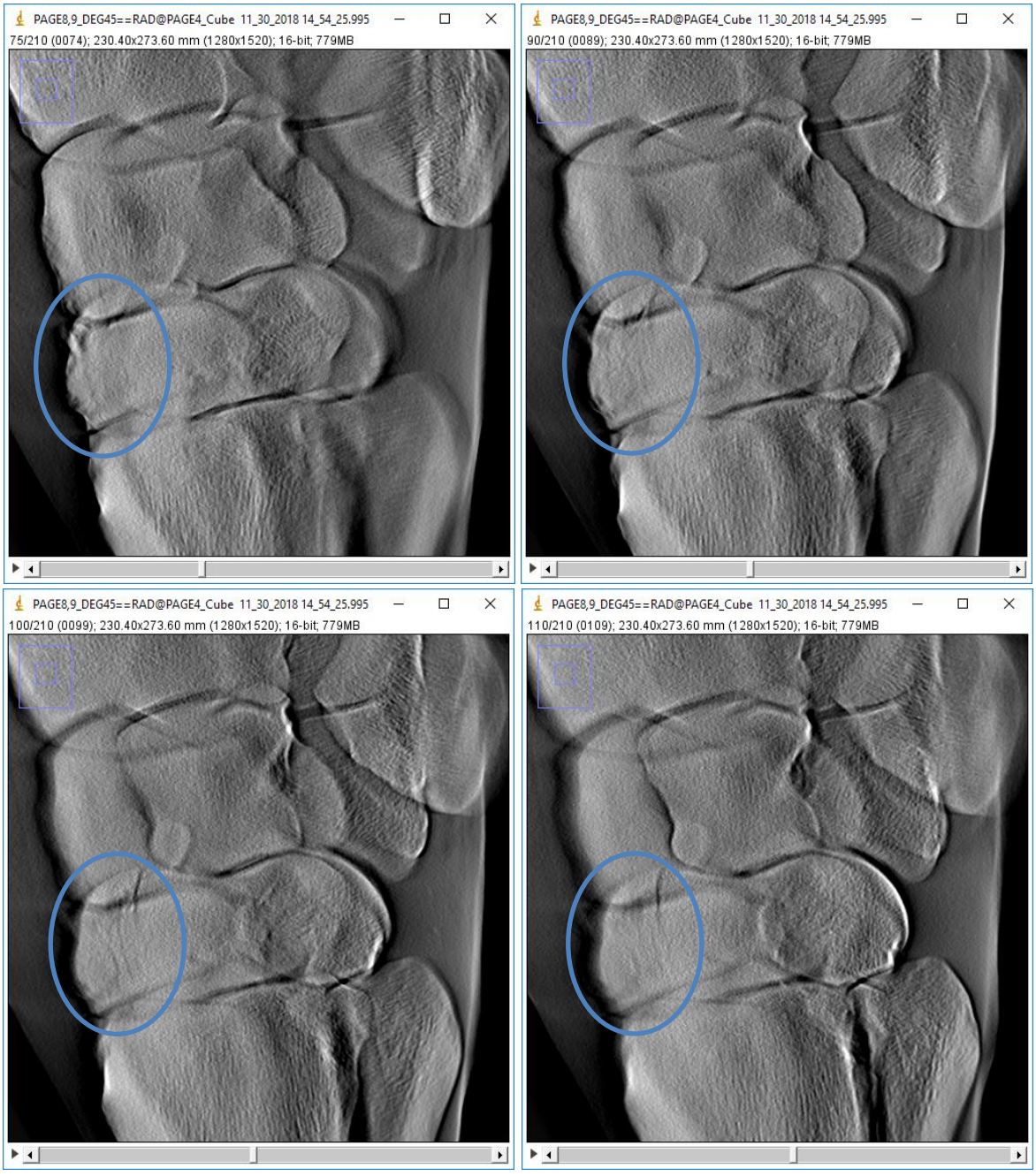

Fig. 5. Slices 75…110

The measured contrast of main cracks in images of tomosynthesis scans at Fig. 3 is K=0.7...0.85, which is twice higher than in the best RAD image at Fig. 1 and 3...8 times more than the original RAD images (pages 1...4). The contrast of other cracks in tomosynthesis is about 0.3, in the RAD image at Fig. 2 these cracks are not visible. Such an increase in contrast was previously shown by us on phantoms and makes the diagnosis more reasonable.

Image at Fig. 1 differs from the rest of the RAD images (pages 1...4) in that it was possible to observe bone fragments against the background of soft tissues. This possibility is not always available. In contrast, a

tomosynthesis scan Fig. 3-5 is performed by superimposing images of fragments in depth. The tomosynthesis technology made it possible to separate and measure the images of the fragments both in the plane and in depth. The cracks in the tomosynthesis layers have a contrast twice higher than the best Skyline RAD image at Fig. 1. In addition, the additional information obtained by tomosynthesis on the right fragment in Fig. 1 consists in the fact that it is not one, but a group of three fragments, but on the left fragment in Fig. 1 not one, but a group of three cracks exists.

To perform an X-ray examination with DR, it was necessary to make 5 RAD shots (pages 1...5) in order to distinguish the image of the fragments from the background of soft tissues. To perform an examination using tomosynthesis, it is sufficient to perform one scan (pages 8...9; Fig. 3-5), in which the superposition of the image of bones and fragments is divided layer by layer by tomosynthesis technology.

1.2. Suspected sclerosis (Fig1, Skyline view).

In the book “JOINT DISEASE IN THE HORSE / ELSEVIER, 2016. – 408 p.” on page 319 we can read:

“It is important to recognize that if the skyline view of the third carpal bone is not sufficiently dorsally protruded, either caused by inadequate flection or inappropriate beam angle, the third carpal bone can look artefactual sclerotic and the corticomeddullary distinction cannot be adequately assessed.”

Perhaps, because no sclerosis is observed on the tomosynthesis layers, we are dealing with the case of the *false positive* diagnosis, and there is no sclerosis on the bone!

In the literature, it is noted that with adequate use of the tomosynthesis of the osteo-articular system, the exclusion of false positive diagnoses based on RAD images is observed in more than 15% of cases.

2. Case “Bxxxxx” – carpal joint.

On RAD images at pages 10, 11 the pathological zones marked by arrows (Fig. 6, 7).

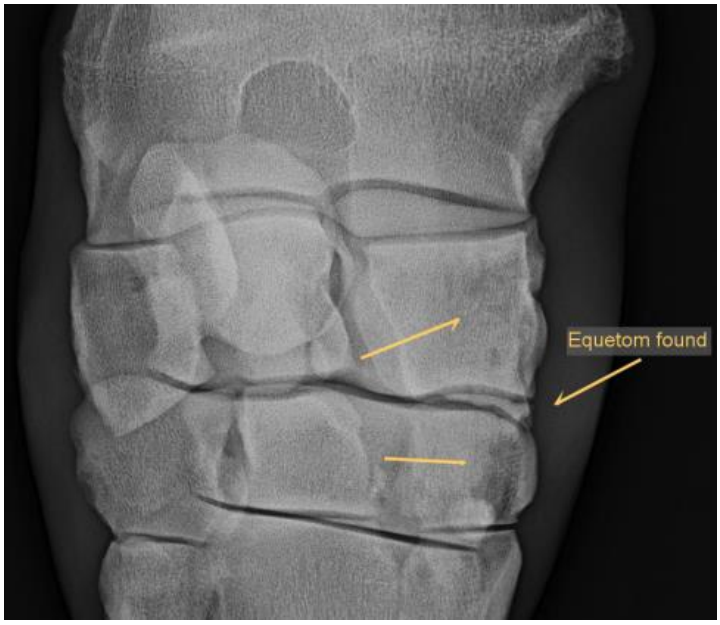

Fig. 6. RAD image DP view (original page 10)

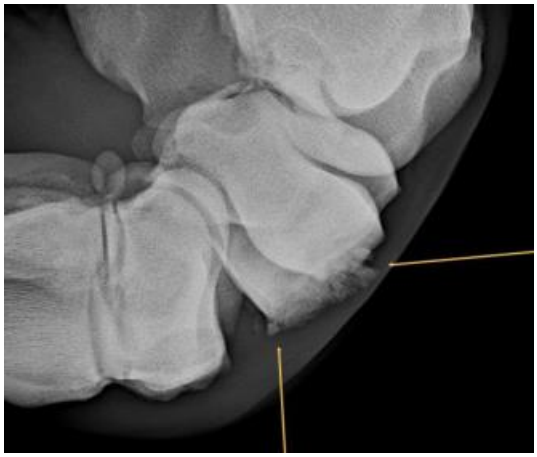

Fig. 7. RAD image LM view (original page 11)

2.1. Top arrow in RAD image at Fig. 6 indicates a suspicious area with a superimposed heterogeneous structure on the image of the bone. To clarify the situation, an additional RAD image at Fig. 7 was acquired, where it is possible to observe the non-uniform formation of 3 fragments against the background of soft tissues. Fragments in the picture Fig. 7 have contrast K=0.5...0.55.

On the tomosynthesis scan #1 at page 18, you can see the structure of 6 fragments with contrast K=0.8...0.85 (Fig. 8).

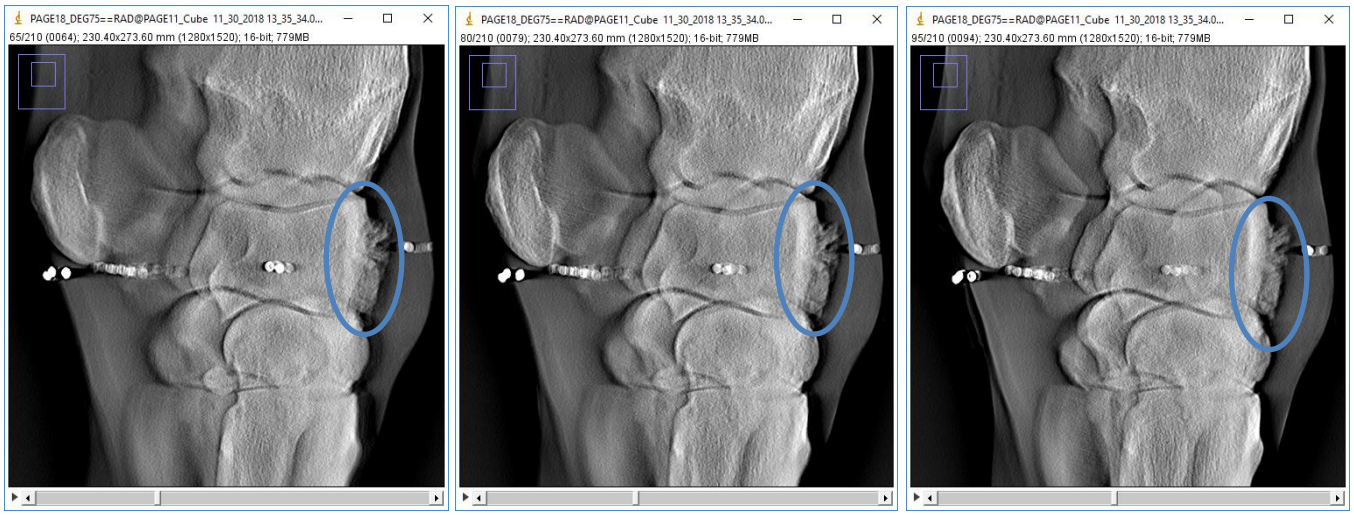

Fig. 8. Slices 65…95

Each fragment is heterogeneous in density. The degree of such inhomogeneity can be measured using the parameter σ - sigma and the average value of the density m - mean. We have tabulated the results of measurements of the fragments' parameters.

№	1	2	3	4	5	6
m	2000	2200	3200	2700	2400	2100
σ	320	320	200	200	650	350
σ/m	0,160	0,145	0,063	0,074	0,271	0,167

The diagnostic value of the above measurement consists in additional information not only about the sizes of the fragments, but also about their structure (internal composition). The contrast of the heterogeneity σ/m is greater than the critical value of 0.05, which allows to visually analyze the structure of the heterogeneity of the fragments.

Further survey of this zone can be performed using the tomosynthesis scan #2 on page 14, the topmost image. On this scan, in layers 203 ... 220 six spots are clearly visible (Fig. 9), which are not visible in the image at Fig. 6. The depth of the spots is about 10 mm. The location is the near-surface area of the bone. The high contrast of spots indicates the destruction of not only the cartilage, but also the bones of the cortical layer.

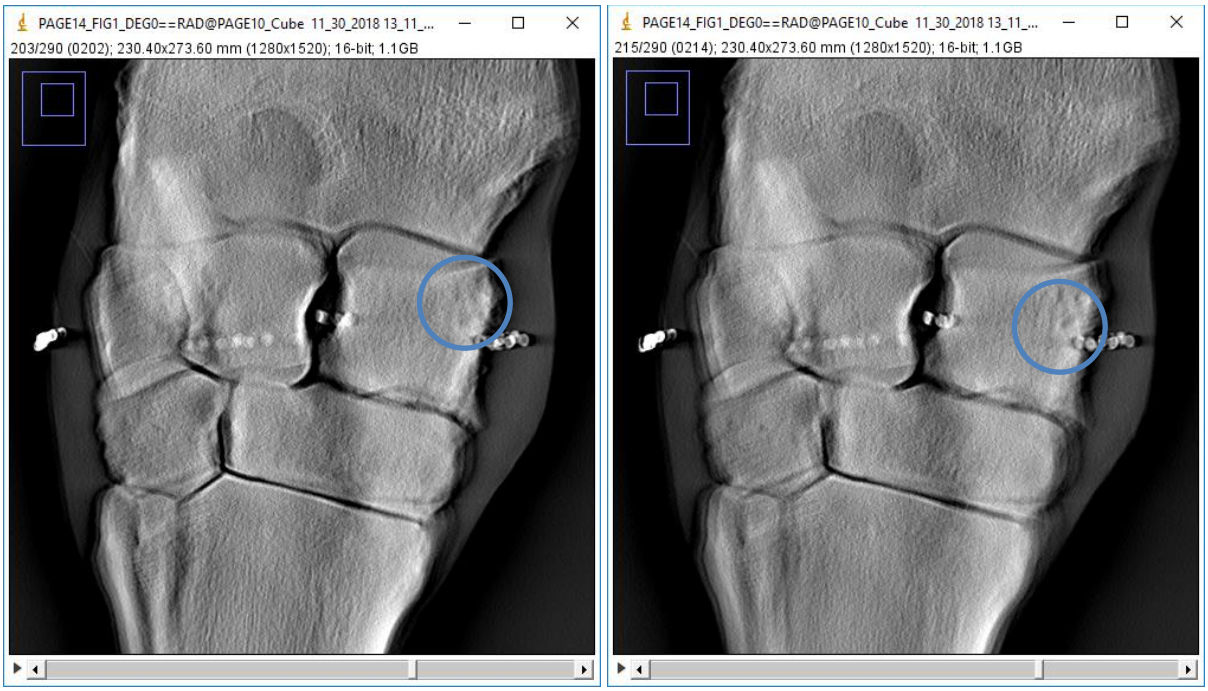

Fig. 9. Slices 203…220

2.2. Lower arrow on RAD image at Fig. 6 indicates a low brightness area. The reason for the reduced brightness may be in the reduced bone density and in the artifact appearance from the heterogeneity of the bone thickness. Closer to the edge, the total thickness of the bone decreases, and an x-ray image at the edges forms a zone with reduced brightness in the negative image, which follows the projection of the dense cortical part of the bone.

To check the reasons for the decrease in brightness, it is convenient to use the additional information acquired by tomosynthesis. On the tomosynthesis scan #2, made in the same projection as the RAD image at Fig. 6, the left outer border of the third carpal bone is clearly visible, causing the artifact to appear in the image at Fig. 6. At the same time, a reduced density is also visible on layers 170...210 of the tomosynthesis scan #2 (Fig. 10).

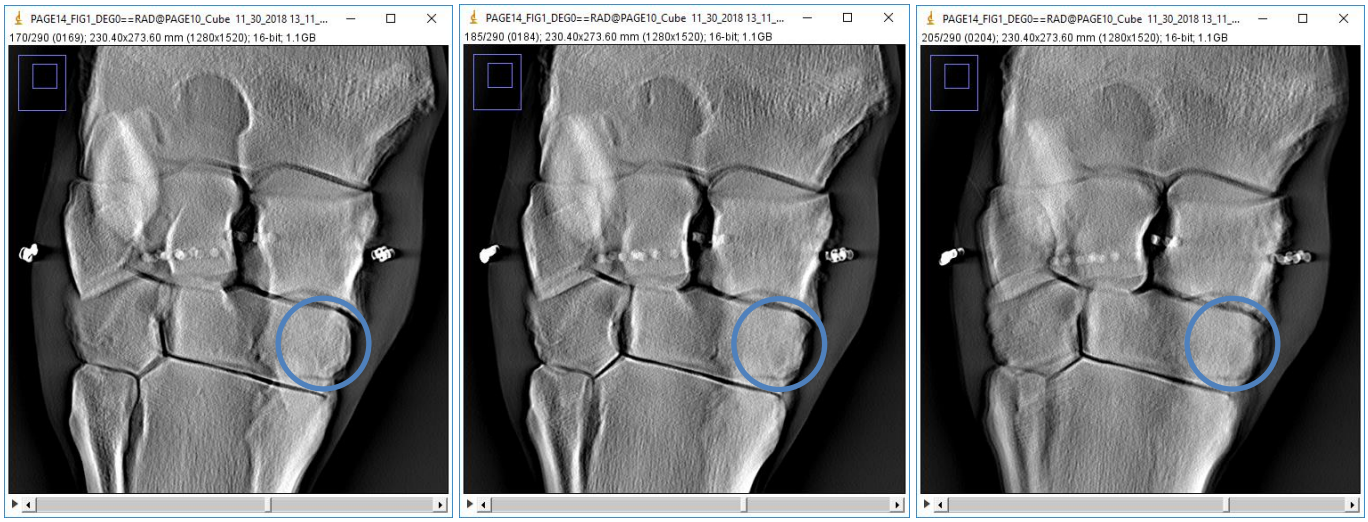

Fig. 10. Slices 170…210

The depth of the low density area is about 24 mm. Thus, tomosynthesis confirmed a decrease in bone density in the zone shown by the lower arrow in the image at Fig. 6. The magnitude of the decrease in bone density is much less than it may seem from the image at Fig. 6. According to our measurements on the tomosynthesis layers, the decrease in bone x-ray density is 8...10%.

2.3. When analyzing the tomosynthesis scan #2 on layers 180…200 of the fourth carpal bone the heterogeneities with high contrast are observed on the left, similar to bone destruction (Fig. 11).

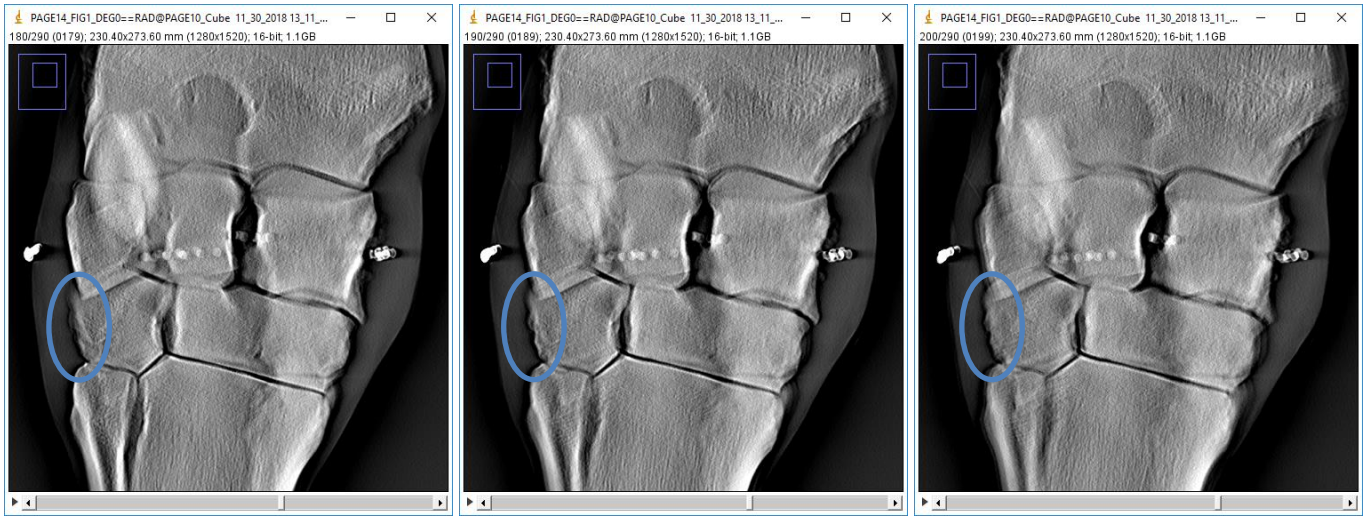

Fig. 11. Slices 180…200

In the image at Fig. 6 these irregularities are poorly visible. It is interesting to know your opinion about the anatomical cause of these heterogeneities.

3. Summary.

The currently used method of radiographic diagnosis of horses' extremities is based on the direct and oblique RAD images acquisition, in which one may seek to eliminate the imposition of bone images and ensure observation of bone pathologies with high contrast against the background of soft tissues. This requires considerable effort, but a positive result is not always achieved.

On the images of the layers acquired by the tomosynthesis method, the influence of the adjacent layers is an order of magnitude less than in radiography. As a result, the contrast of the objects of observation increases several times. On the given cases using EqueTom the measured contrast increases by 2...8 times. A similar estimate was previously reached on phantoms. This makes it possible to get a large amount of additional information when analyzing images of tomographic layers. This applies both to an increase in the observed number of fragments of pathologies, and the exclusion of false positive diagnoses. The possibility of layer-by-layer observation of defects in the internal structure of the bone (changes in bone density, destruction of trabecula, etc.) and measurement of their position and size in the plane of the layer and in depth appears.

The above two cases compare the effectiveness of radiography and tomosynthesis in the diagnosis of horses. Both of them are performed on the most complex carpal joint. It is methodically correct to begin the analysis with simpler cases for the limbs and the horse's head.