Gross and histological evaluation of early lesions of navicular bone and deep digital flexor tendon in horses

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Abstract

The study aimed at evaluation of pathological lesions on flexor surface of navicular bone and deep digital flexor tendon in horses graded in standard X-ray examination as 2 (fair). The evaluation was performed on fifteen horses (6-9 years of age). Analysis procedure involved examining navicular bones on X-ray pictures, post-slaughter preparation of navicular bones from the hoof capsule, macroscopic evaluation of fibrocartilage on flexor surface, and analysis of histologic preparations. In horses with navicular bones graded as 2, early pathological changes have already developed, even if such horses were not lame. The pathological changes included fibrillation and disruption of deep digital flexor tendon surface, loss of fibrocartilage in sagittal ridge area of navicular bone, thinning of subchondral bone on its flexor surface, and fibromyxoid changes in chondroid matrix. In terms of clinical relevance, more studies are needed to understand the sequence of changes in a better way.

Key words: horses, navicular bone, deep digital flexor tendon, lameness, hoof.

Introduction

In clinical literature concerning horses, the distal sesamoid bone usually refers to navicular bone. Pathological changes of this small structure are a common problem of numerous relatively young saddle horses. The form of such pathologies varies and they might progress with time. In many cases, a characteristic lameness develops and progresses with time, leading to the uselessness of the horse. Enlarged nutrient foramina on distal border of the bone and thinner layer of cortical bone on flexor surface tend to be the first symptom of abnormalities (4, 8). Such lesions can be found on X-ray pictures. This situation is related to questions still unanswered by research, namely what is happening on navicular surface before lesions can be detected on an X-ray; what is the condition of cartilage tissue covering the navicular bone; and do relatively small lesions always grow and induce lameness?

Navicular bones in horses are usually graded according to 0-4 scale (6). Healthy navicular bones are graded as 0 (excellent), and the bones with extreme lesions are graded as 4 (bad). Doubts usually arise in the case of young horses with navicular bones graded as 2 (fair). This is a mid-scale value, which makes it difficult to evaluate whether the condition is still normal or already pathology. Such horses are not lame and often successfully compete, although the length of their career is uncertain. It is very difficult to clearly state if navicular bones graded as 2 will be graded as 3 or 4 with time, or not. Thus, the knowledge of the gross and histological image of both normal and pathological navicular bones is crucial. Navicular bone graded as 2 may show several moderate abnormalities on an X-ray, including poor definition between the palmar cortex and the medulla. This is often accompanied by a depression in the sagittal ridge on the flexor surface of navicular bone to be observed on an X-ray in lateromedial view. According to many authors, the sagittal ridge might be the first structure on which resorption of osseous tissue takes place (7, 12).

The aim of the study was to perform gross and
histological evaluation of navicular bones graded as 2 (fair), and compare them with completely normal navicular bones. Our attention was focused particularly on the flexor surface of the navicular bone, a structure being in contact with deep digital flexor tendon (DDFT). The result of the study may help predict the future of horses with early navicular lesions.

Material and Methods

**Horses.** The study included 15 navicular bones from 11 geldings, three mares, and one stallion, all Polish Halfbred horses (one foreleg from each horse). The horses were slaughtered for reasons not related to the subject of the research, according to the procedures for meat production. The horses were six to nine years of age and free from diagnosed navicular syndrome and any lameness.

**Analysis procedure.** Following X-ray examination, it was found that eight navicular bones were free from any pathological lesions. For the purpose of clear presentation of results, this group was labelled as Group A. The remaining seven bones, with moderate lesions, were assigned to Group B. According to standard rules, group B navicular bones were graded as 2 on a 0-4 scale (6). All studied bones were X-rayed in lateromedial and dorsopalmar projections. After preparation of the bones from the hoof (the distal part of the limb was cut along the coronary band, followed by extraction of the navicular bone from the distal interphalangeal joint), gross evaluation of the condition of fibrocartilage covering the navicular bone was performed. Afterwards, navicular bones with adherent tissues and DDFT were fixed in 10% formalin. Then, specimens were collected and decalcified for 24 h in 5% nitric acid. Then, the material was embedded routinely in paraffin blocks. Preparations were stained with haematoxylin and eosin and evaluated under light microscope.

Results

**Macroscopic analysis.** In the case of three navicular bones of group B, X-ray (lateromedial projection) showed the depression in the sagittal ridge (Fig. 1). After their preparation, the three navicular bones were subjected to gross evaluation. Loss of fibrocartilage was found on flexor surface: in one case it was punctate and placed immediately by the sagittal ridge; in two remaining cases the loss was transverse to the sagittal ridge and considerably long (Fig. 2). On other preparations of group B navicular bones, depressions in fibrocartilage in the central part of the bone were also observed; however, these lesions were less visible in gross evaluation.

**Histological analysis.** Cross-sections of navicular bones from both groups were compared histologically. In normal navicular bones, palmar cortex was much thicker in comparison to the bones with lesions, *i.e.* ones from group B (Fig. 3 and Fig. 4).

Microscopically, fibrocartilage of flexor surface in group B navicular bones was desquamating (Fig. 5). In group A of navicular bones this surface was smooth. Thinning of cartilage was most advanced in the sagittal ridge area. In one of group B bones, fibromyxoid changes were found in this area, accompanied by drop in chondrocyte numbers (Fig. 6).

Histological preparations of DDFT and its contact area with navicular bone was also analysed. In group B bones, the tendon margin sliding over the navicular bone was fibrillated, while tendons of group A horses were smooth in this region (Fig. 7). Moreover, in the peripheries of normal tendons chondrocytes were arranged regularly (Fig. 8).
Fig. 3. Top: normal navicular bone; fibrocartilage is thick along the whole surface (white arrow); subchondral bone is also thick and dense (asterisk). Bottom: navicular bone with minor loss of cartilage in sagittal ridge area (black arrow); this depression is not showing on X-ray pictures; subchondral bone is still thick.

Fig. 4. Examples of advanced erosion of fibrocartilage and associated loss of thickness of subchondral bone in some horses from group B.

Fig. 5. Left: smooth fibrocartilage (arrow) in a control group horse. Right: navicular bone with fibrillated fibrocartilage on flexor surface; H. & E., 100x.

Fig. 6. Degenerative lesions of fibrocartilage with loss of chondrocytes; H. & E., 40x. The close-up shows a fibromyxoid focus located directly under subchondral bone; H. & E., 100x.
Fig. 7. Fibrillation of the surface of deep digital flexor tendon in the place of contact with navicular bone; H. & E., 40x. The close-up shows the separated fragment with grouped chondrocytes; H. & E., 200x

Fig. 8. Normal DDFT of a horse from the group A. Chondrocyte-rich zone found on tendon surface. H. & E., 200x

Discussion

Results of the study demonstrated that navicular bones graded according to standard classification as 2, presented significant histological marked lesions. The observations were focused on flexor surface of navicular bone which is subjected to mechanical pressure exerted by DDFT. According to many authors, the activity of the tendon is a direct reason for formation of cyst-like lesions in subchondral bone in advanced stage of navicular disease (8, 2). This is accompanied by abnormalities in remodelling process of osseous tissue, leading to deterioration of repair mechanisms (12, 14). However, before the degenerative changes become so evidenced, moderate symptoms of wear of adjacent anatomical structures develop in the initial stage, including DDFT. For instance, Doige and Hoffer (5) showed that tendon surfaces were fibrillated and disrupted in all studied horses with clinical history of navicular disease. The authors, however, stated that these lesions might be also found in sound older horses (over ten years of age). In our studies, group B bones were below 10 years of age, yet in all cases tendon surfaces were fibrillated. Therefore, lesions in DDFT are an alarming signal, even if there is no lameness involved. Our research confirmed the fact that normal tendon is surrounded with a regular layer of chondrocytes in the place of contact with navicular bone. The more abaxial parts of the DDFT commonly show a transition from a tendon fascicular structure to fibrocartilaginous tissue (3). In our research, complexes with grouped chondrocytes become separated in the process of tendon fibrillation. These fragments remain between the tendon and navicular bone and rub against these structures, thus leading to possible damages of fibrocartilage directly protecting the navicular bone. This observation is yet to be confirmed by further research.

Our analyses also confirmed the observation that fibrocartilage becomes thinner in sagittal ridge area in initial phase of lesions. As fibrocartilage is undergoing the thinning process, at the same time the subchondral bone is gradually becoming thinner as well. These observations were described earlier, for instance by Wright et al. (15). These authors also suggested that fibromyxoid lesions might form during loss of fibrocartilage, but this observation was not confirmed in the studies of Blunden et al. (2). We have found such fibromyxoid lesion in chondroid matrix in one navicular bone, with its focus located indirectly under subchondral bone.

In the case of subchondral bone thinning process, it should be remembered that depending on several factors, this layer might have a natural tendency to change its thickness. Horses with upright foot tend to have thinner subchondral bone (6). Breed and body mass factor also play their part: less subchondral (cortical) bone in comparison to cancellous (spongy) bone was observed in light horses and ponies than in draft horses and heavy ponies (10). However, the most important issue seems to be the activity level of individual horse, and the related normal bone remodelling, i.e. the response of osseous tissue to exercise (13). Horses in training usually have increased thickness of subchondral bone and greater density of cancellous bone as compared to horses which
are not exercised. In practice, however, navicular bone diseases are common in sport horses. Therefore, it is crucial to find out what is the stress threshold over which the lesions might develop. Pathological navicular bones have higher flexor surface, which means that osseous tissue is subject to functional adaptation to increased pressure from DDFT (11). We suspect that frequent training on heavy, soft ground, which allows the hoof to sink in, leads to problems with navicular bone, as such ground makes DDFT strongly rub against the podotrochlear bursa and flexor surface of navicular bone. This may be accompanied by remodelling abnormalities resulting from uncoupled basic multicellular unit and a greater number of microcracks in bone matrix (1).

The observations and results of our research lead to the conclusion that in horses graded as 2 in a standard X-ray examination, pathological lesions have already started to develop. They include fibrillation and disruption of DDFT, and thinning of fibrocartilage and subchondral bone. Such conclusions definitely cause the need to reconsider training methods for such horses, and to pay attention to external conformation of their hoof capsules (9). Further studies on the development of navicular diseases should focus on relationship between the condition of navicular bone and stresses coming from exercise. The theory about toe-first or heel-first landing of the hoof also seems to be interesting. Thus, we suspect that there are several factors leading to gradual accumulation of lesions in navicular bones. Nevertheless, in horses below 10 years of age, navicular bone graded as 2 may be considered as an alarming signal.

References