Praca oryginalna *Original paper*

Magnetic resonance imaging provides a detailed perspective on the navicular syndrome in horses

MARTA MIESZKOWSKA, ZBIGNIEW ADAMIAK, MARCIN MIESZKOWSKI*, PIOTR HOLAK, KATARZYNA WOLIŃSKA**

Department of Surgery and Radiology, Faculty of Veterinary Medicine, University of Warmia and Mazury in Olsztyn, Oczapowskiego 14, 10-719, Olsztyn, Poland
*Anesthesia and Intensive Care Clinical Unit, Regional Specialist Hospital, Żołnierska 18, 10-561, Olsztyn, Poland
**Department of Horse Breeding and Equestrian Studies, University of Warmia and Mazury in Olsztyn, Prawocheńskiego 2, 10-720 Olsztyn, Poland

Received 11.03.2015 *Accepted 20.01.2016*

Mieszkowska M., Adamiak Z., Mieszkowski M., Holak P., Wolińska K.

Magnetic resonance imaging provides a detailed perspective on the navicular syndrome in horses

Summary

The navicular syndrome is a chronic bilateral forelimb lameness which is abolished by palmar digital nerve block. Its pathogenesis is not clearly understood. The aim of this study was to evaluate pathological changes in horses where chronic bilateral forelimb lameness was abolished by palmar digital nerve block.

The experiment was performed on 20 horses. The animals were referred for 0.25 T MRI scanning with the use of T1-weighted, T2-weighted, STIR, X-bone and 3D HYCE sequences.

In 15 horses (75%), the changes were localized in the area of the deep digital flexor. In nine horses (45%), changes were observed in the area of the collateral sesamoid ligament. In five horses (25%), the recess of the navicular bursa was enlarged and filled with large amounts of synovial fluid which was indicative of an inflammation. In 13 horses (65%), changes in the navicular apparatus were caused by widening of synovial membrane invaginations into the palmar aspect of the navicular bone.

Magnetic resonance is an imaging modality which provides a detailed picture of pathological changes, supports the choice of optimal treatment, and facilitates prognosis for horse's return to use and performance.

Keywords: magnetic resonance imaging, horse, navicular syndrome, podotrochlear apparatus

The navicular syndrome is one of the most frequently reported disorders of the podotrochlear apparatus in horses. This chronic forelimb lameness is alleviated by analgesia of the palmar digital nerves. Pathological changes affect the flexor surface of the navicular bone and the accompanying structures, including the deep digital flexor tenor, its attachment to the distal phalanx, navicular bursa, distal sesamoid impar ligament and collateral sesamoid ligament (Fig. 1). The navicular syndrome is reported mainly in older animals with a history of athletic performance, including sport horses and race horses, but it may also affect younger horses. Research has demonstrated that horses may be genetically predisposed to develop navicular bones with a concave proximal surface which is observed in the navicular syndrome. The navicular apparatus is under greatest strain when the limb is removed from the ground, i.e. at the very end of the weight bearing phase of the stride, and when digital joints are maximally extended. The deep digital flexor tendon exerts increased pressure on the flexor surface of the navicular bone; the navicular bone comes into close contact with the middle phalanx, which increases the strain of the collateral ligament (3). The shape of the hoof plays an important role in injuries of the navicular apparatus. Low heels increase the load on the deep digital flexor tendon and contribute to its damage because every decrease in hoof angle increases the strain on the deep digital flexor tendon by 4% (11). Very narrow hoofs or very tall heels can also disrupt hoof mechanics and block blood flow in digital vessels, which contributes to degenerative changes. A wider angle between the distal phalanx and the sole increases the risk of damage to the navicular bone and the deep digital flexor tendon, but in such cases the navicular bone is rarely injured in isolation (14). Horses with the navicular syndrome were diagnosed with partial or complete occlusion of digital arteries, whereas only focal narrowing of digital arteries was observed incidentally in healthy individuals (12). Excessive loading can lead to hypoxia within the hoof, whereas prolonged rest contributes to venous stasis in digits and lowers the supply of

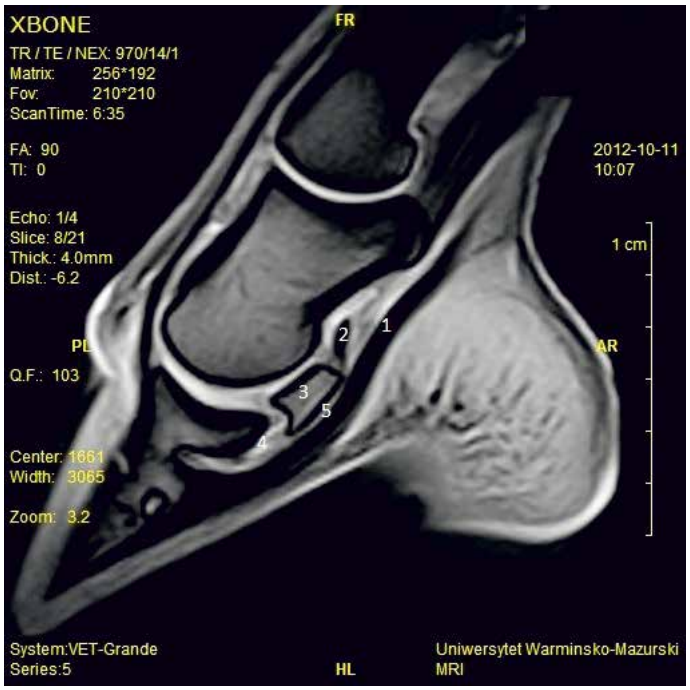

Fig. 1. Thoracic limb of a 5-year-old gelding without lameness. Normal structure of the navicular apparatus: 1 – deep digital flexor tendon, 2 – collateral sesamoid ligament, 3 – navicular bone, 4 – distal sesamoid impar ligament, 5 – navicular bursa

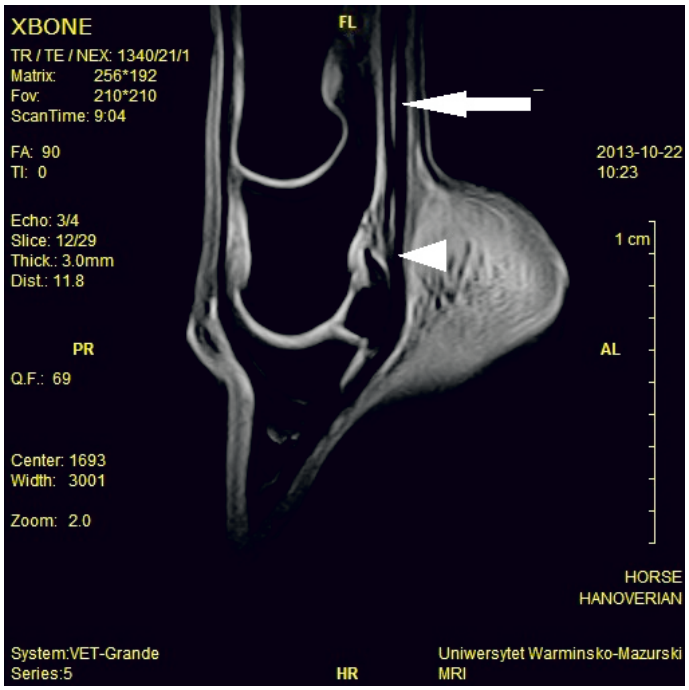

Fig. 2. X-bone sequence in the sagittal plane. Patient 1 with chronic lameness of the left thoracic limb alleviated by analgesia at the base of the sesamiod bones. Visible core lesion in the deep digital flexor tendon at mid-length of the proximal phalanx, extending distally to the proximal end of the middle phalanx (arrow). Dorsal lesion of the deep digital flexor tendon at the level of the navicular bursa and the collateral sesamoid ligament

nutrients and oxygen to hoof structures (2). Structural deformations caused by mechanical stress increase the number of trabeculae in cortical bone, swelling and progressing degeneration of the navicular bone (19). Due to the location of internal hoof structures, routine examinations may not provide comprehensive information about the reach and type of pathological changes. Radiography is usually the diagnostic method of choice, but in some patients, radiological changes were not observed despite a positive response to palmar digital nerve block (4, 6). The flexor surface of the navicular bone, the distal segment of the superficial digital flexor tendon and the distal sesamoid impar ligament can be evaluated ultrasonographically (4). Despite the above, longitudinally arranged tendon fibers cannot be analyzed in detail with a sector scanning probe, whereas the linear ultrasound probe, which is recommended for tendon examinations, cannot be maneuvered with great precision in the frog area. During magnetic resonance imaging, bones and soft tissues can be analyzed jointly. The resulting images are presented in several planes and sections, and the observed pathological changes can be viewed spatially. MRI scans provide information about the exact location and range of pathological changes. The type and severity of the observed changes (acute, chronic) can be evaluated by choosing and comparing the optimal MRI sequences (15).

The aim of this study was to evaluate pathological changes in horses where chronic bilateral forelimb lameness was abolished by palmar digital nerve block. The animals were subjected to MRI scanning because routine radiographic exams did not provide sufficient data about pathological changes inside the hoof capsule. Radiographic abnormalities were not noted in any of the patients, and the source of pain was not localized. The causes of lameness were established based on the data provided by MRI scans. The resulting information was used to plan treatment and offer a prognosis for the animals' return to use and performance.

Material and methods

The experiment was performed on 20 horses with signs of bilateral forelimb lameness that was alleviated by palmar digital nerve block. The examined group included 14 geldings and six mares, aged 7-15 years (11 years on average), of various warmblood breeds. All animals had participated in jumping competitions with 100-140 cm obstacle heights. Horses that responded positively to analgesia of the palmar digital nerves were classified as animals with the navicular syndrome, but additional tests had to be performed to confirm the initial diagnosis. Radiological changes in the area of the anesthetized limb were not observed in any horses, the source of pain was not localized, and further examinations were needed to make the diagnosis and predict the outcome. The animals were referred for MRI scanning at the Department of Surgery and Radiology of the Faculty of Veterinary Medicine, University of Warmia and Mazury in Olsztyn. The MRI examination was performed under general anesthesia. The animals were sedated with xylazine at 0.8 mg/kg BW IV, and general anesthesia was induced with diazepam at 0.05 mg/kg BM IV and ketamine at 2.2 mg/kg BW IV. Anesthesia was maintained by inhalation of

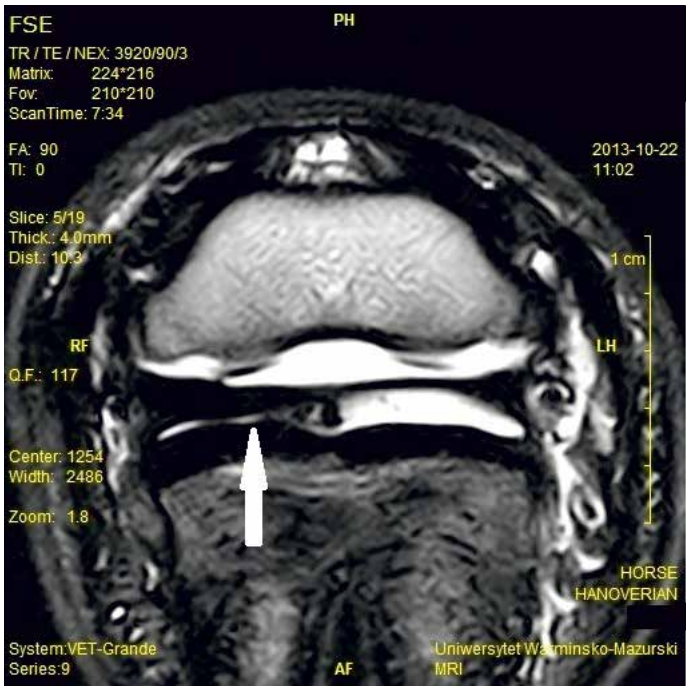

Fig. 3. Patient 1, cross-section of the limb shown in Fig. 2. Visible narrowing of the medial recess of the navicular bone suggesting the presence of adhesions between the deep digital flexor tendon, navicular bursa and collateral sesamoid ligament

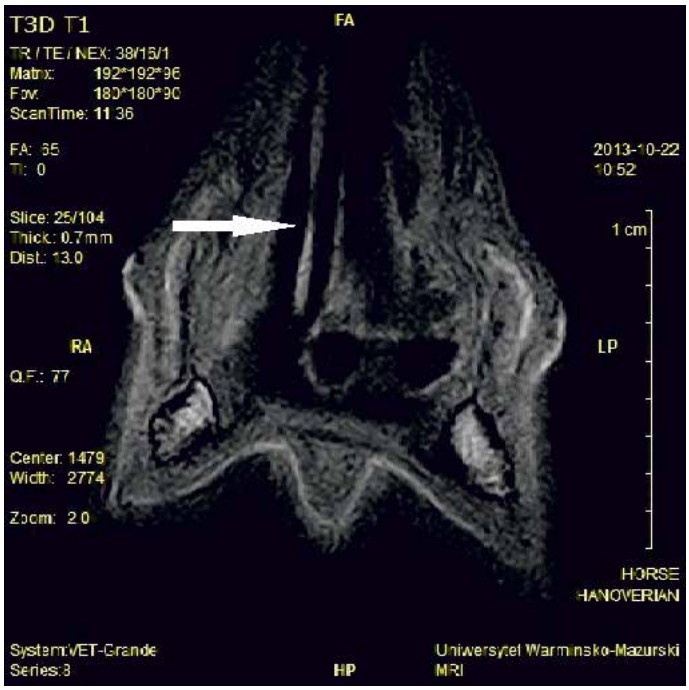

Fig. 4. Patient 1, cross-section of the limb shown in Figure 2, T1-weighted sequence in dorsal plane. Visible hyperintensive core lesion on the medial side of the deep digital flexor tendon

isoflurane. The patients were examined in an open low-field (0.25 T) MRI scanner (Esaote, Vet-MR Grande) with the use of a coil designed to guarantee high sensitivity in the region of interest – the hoof. The hoof was visualized in T1-weighted, T2-weighted, STIR, X-bone and 3D HYCE sequences.

Results and discussion

Pathological changes in soft tissues surrounding the navicular apparatus were observed in all patients. In 15 horses (75%), the changes were localized in the area of the deep digital flexor, and they included core lesions, sagittal splits and dorsal abrasions. Pathological changes were not noted in the area where the deep digital flexor tendon attaches to the distal phalanx. In nine horses (45%), changes were observed in the area of the collateral sesamoid ligament with focal changes in signal intensity and ligament thickening, and in two of those animals, fluid accumulation was noted in the recess of the distal interphalangeal joint. In horses whose collateral ligaments appeared to be damaged, the presence of adhesions was suspected due to increased signal intensity and obliterated contours of the collateral ligament, navicular bursa and deep digital flexor tendon. In five horses (25%), the recess of the navicular bursa was enlarged and filled with large amounts of synovial fluid, which was indicative of an inflammation. In one animal, one of the recesses was constricted, and pathological changes were observed in the deep digital flexor and the collateral sesamoid ligament (Fig. 3). In 13 horses (65%), changes in the navicular apparatus were caused by the widening of synovial membrane invaginations into the palmar aspect of the navicular bone. In one horse, a cyst was noted on the distal surface of the navicular bone (Fig. 6).

Higher signal intensity in the STIR sequence in the navicular bone could be indicative of hematoma, synovial fluid, osteonecrosis, fibrosis or inflammation (18, 19). According to Sampson et al. (19), navicular inflammation is not the primary cause of lameness, and the build-up of synovial fluid in the recess of the navicular bursa generally accompanies other pathological changes in the collateral ligament, impar ligament and deep digital flexor tendon, and it never occurs as an isolated condition.

Injuries to the deep digital flexor tendon can be divided into four categories: core lesions, dorsal abrasions, sagittal splits, and damage to the tendon insertion into the distal phalanx (2, 22). Core lesions are foci of collagen necrosis, fibroplasia and fibrocartilaginous metaplasia (20). Interstitial fibroblasts migrate to the center of the fiber where they differentiate into chondrocytes, and the degeneration of collagen fibers leads to gradual necrosis. Those changes are caused by disruption of the blood supply to the tendon, which confirms the theory that injuries to the deep digital flexor involve degenerative changes rather than sudden tendon rupture (13). The cross-sectional area of the tendon increases in core lesions, but not in other types of injuries (17). Dorsal abrasions generally accompany inflammations of the navicular bursa, which was noted in patient 1 (Fig. 2). In histopathological evaluations, they are present as fibrillations with fragmentation of collagen fibers or erosion. Fibrillations are accompanied by adhesions between the tendon and the palmar surface of the navicular bone, collateral ligament and/

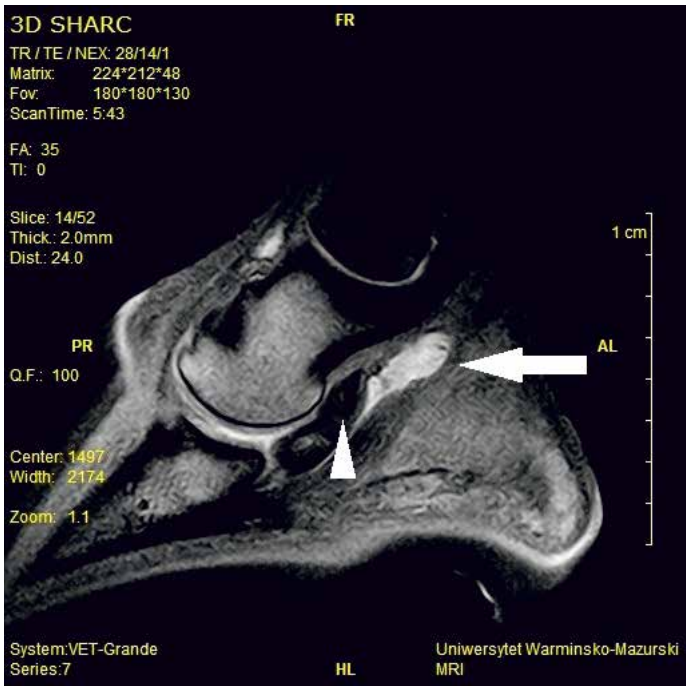

Fig. 5. Patient 2. Lameness of the right thoracic limb alleviated by palmar digital nerve block at mid-length of the proximal phalanx. 3D SHARC sequence in sagittal plane. Significant widening of the recess of the navicular bursa (arrow) and thickening of the collateral sesamoid ligament (arrowhead)

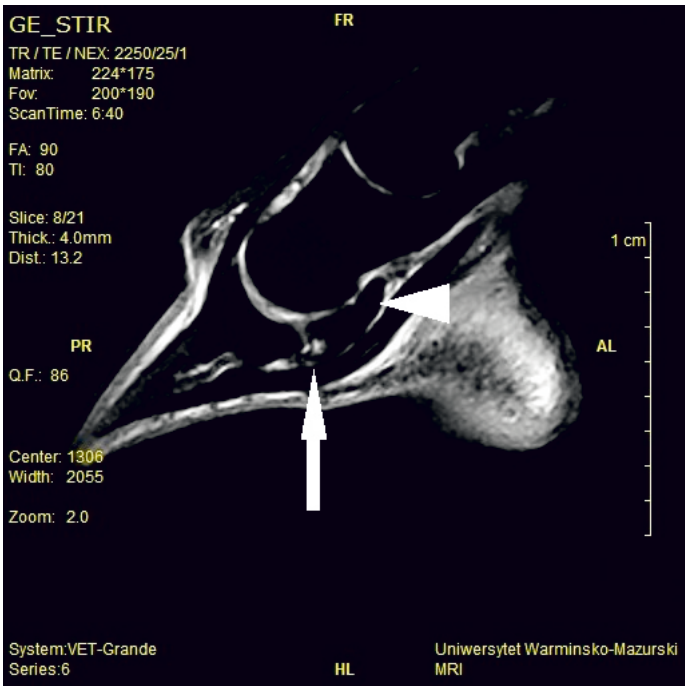

Fig. 6. Patient 2. Right thoracic limb, STIR sequence in sagittal plane. In addition to the thickening of the collateral sesamoid ligament (arrowhead), a cyst is visible on the distal surface of the navicular bone by the impar ligament and the recess of the distal interphalangeal joint (arrow)

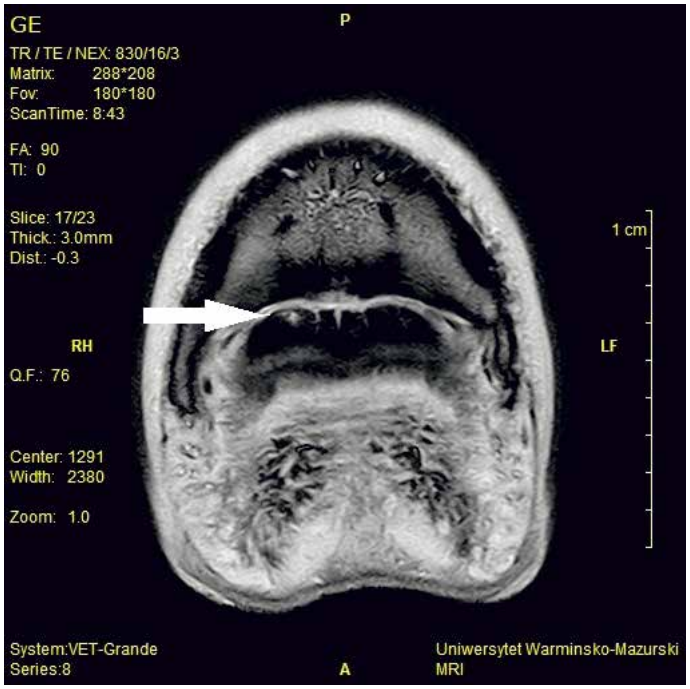

Fig. 7. Patient 2. Cross-section of the right thoracic limb in the Gradient Echo sequence. Visible cyst at the cranial aspect of the navicular bone (arrow)

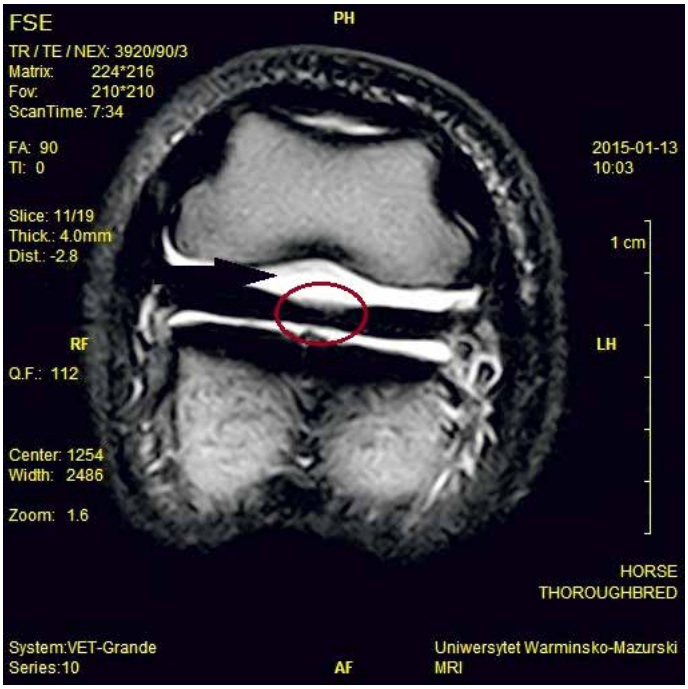

Fig. 8. Cross-section of the left thoracic limb of a two-year-old English thoroughbred mare in T2-weighted FSE sequence. Lameness was alleviated by analgesia performed at the base of the sesamoid bones. MRI revealed desmopathy of the collateral sesamoid ligament (circle) with fluid build-up in the palmar recess of the distal interphalangeal joint (arrow) and irregular dorsal surface of the deep digital flexor tendon

or impar ligament of the navicular bone (20). Sagittal splits are generally observed at the level of the navicular bursa on the surface or across the entire tendon. Injuries to the insertion of the deep digital flexor tendon appear in the form of small core lesions, sagittal splits or osseous abnormalities at the insert, and they may be accompanied by local loss of the cortical layer, the presence of bone cysts, periosteal reactions and sclerotic foci (20). Desmopathy of the collateral sesamoid ligament is difficult to diagnose due to non-specific clinical symptoms and difficulties with maneuvering

the ultrasound probe. Injuries of the collateral ligament may be accompanied by fluid build-up in the recess of the distal interphalangeal joint, which can be observed during routine ultrasound examinations (Fig. 8) (8, 9).

In MRI scans, regeneration processes involving fibrous tissue are characterized by decreased signal intensity in T2-weighted and STIR sequences, whereas signal intensity in T1-weighted sequences remains high. High signal intensity in T2-weighted and STIR sequences was observed in more extensive injuries involving tendon tear and the formation of pseudocysts (5, 20).

In this study, horses were referred to the clinic for MRI scans only, and they were not treated at the Department of Surgery and Radiology. For this reason, the authors are not familiar with treatment outcomes. In injuries of the deep digital flexor tendon, the prognosis is guarded, and in a study by Dyson et al. (10), athletic soundness was restored in only 28% of horses. Treatment of deep digital flexor injuries involves box confinement for a minimum of six months with short daily walks on reins. According to Smith et al. (23), bursoscopy facilitates the removal of torn tendon fibers from the navicular bursa. Regenerative medicine offers a variety of effective treatment options, including injection of growth factors or stem cells directly to the site of injury. The only risk associated with the above procedure arises from the administration of the preparation to scar tissue, which can lead to mechanical rupture of tendon fibers and much greater damage (21). To minimize the range of injuries, injections can be administered directly to the navicular bursa (1), but not earlier than two weeks after bursoscopy. According to Kofler et al. (16), a full hoof cast extending over the entire metacarpus is most effective in the treatment of desmopathy of the collateral ligament with local injury and swelling of the navicular bone. The cast is left in place for four weeks, after which the hoof is compressed with Robert Jones bandage. In the cited study, the podotrochlear apparatus was completely healed in six months. Tiludronate is also effective in the treatment of the navicular syndrome, in particular when pathological changes in the navicular bone are confirmed radiologically. Tiludronate is a bisphosphonate which inhibits bone resorption and induces osteoclast apoptosis. Denoix et al. (7) demonstrated the usefulness of tiludronate, administered at a dose of 1.0 mg/kg BW, in the treatment of the navicular syndrome, but only minor improvement was reported in animals with chronic lameness. Tildren is an effective therapeutic agent when pathological changes affect bones. In horses with podotrochlear syndrome, pathological processes are observed also in soft tissues; therefore, MRI scans are required to determine the optimal treatment. In each case special attention should be paid to the structure and alignment of the hoof to restore hoof mechanics, improve blood flow and cushioning dynamics.

Magnetic resonance imaging is recommended in all cases of lameness that is alleviated by palmar digital nerve block. It provides a detailed picture of pathological changes, supports the choice of optimal treatment, and facilitates the prognosis for the horse's return to use and performance.

References

1. *Barry F. P.*: Regeneration of musculoskeletal tissues using mesenchymal stem cells. Proc. Am. Coll. Vet. Surg. 2007, 17, 118-120.
2. *Blunden A., Murray R., Dyson S.*: Lesions of the deep digital flexor tendon in the digit: A correlative MRI and post mortem study in control and lame horses. Equine Vet. J. 2009, 41, 25-33.
3. *Bowker R. M., Atkinson P. J., Atkinson T. S., Haut R. C.*: Effect of contact stress in bones of the distal interphalangeal joint on microscopic changes in articular cartilage and ligaments. Am. J. Vet. Res. 2011, 62, 414-424.
4. *Busoni V., Denoix J. M.*: Ultrasonography of the podotrochlear apparatus in the horse using a transcuneal approach: technique and reference images. Vet. Radiol. Ultrasound. 2001, 42, 534-540.
5. *Busoni V., Heimann M., Trentseaux J., Snaps F., Dondelinger R. F.*: Magnetic resonance imaging findings in the equine deep digital flexor tendon and distal sesamoid bone in advanced navicular disease- an ex vivo study. Vet. Radiol. Ultrasound. 2005, 46, 279-286.
6. *Campbell J. R., Lee R.*: Radiological techniques in the diagnosis of navicular disease. Equine Vet. J. 1972, 4, 135-138.
7. *Denoix J. M., Thibaud D., Riccio B.*: Tiludronate as a new therapeutic agent in the treatment of navicular disease: a double-blind placebocontrolled clinical trial. Equine Vet. J. 2003, 35, 407-413.
8. *Dyson S., Murray R.*: Collateral desmitis of the interphalangeal joint in 62 horses (January 2001-December 2003), [in:] Proc. 50th Annual Convention Am. Ass. Equine Practitioners, December 4-8, 2004, Denver, CO, p. 248-256.
9. *Dyson S., Murray R., Schramme M.*: Lameness associated with foot pain: results of magnetic resonance imaging in 199 horses (January 2001-December 2003) and response to treatment. Equine Vet. J. 2005, 37, 113-121.
10. *Dyson S., Murray R., Schramme M., Branch M.*: Magnetic resonance imaging of the equine foot: 15 horses. Equine Vet. J. 2003, 35, 18-26.
11. *Eliashar E., McGuigan M. P., Wilson A. M.*: Relationship of foot conformation and force applied to the navicular bone of sound horses at the trot. Equine Vet. J. 2004, 36, 431-435.
12. *Fricker C. H., Riek W., Hugelshofer J.*: Occlusion of the digital arteries – A model for pathogenesis of navicular disease. Equine Vet. J. 1982, 14, 203-207.
13. *Gigante A., Marinelli M., Chellemi C., Greco F.*: Fibrous cartilage in the rotator cuff: A pathogenetic mechanism of tendon tear? J. Shoulder Elbow Surg. 2004, 13, 328-332.
14. *Holroyd K., Dixon J. J., Mair T., Bolas N., Bolt D. M., David F., Weller R.*: Variation in foot conformation in lame horses with different foot lesions. Vet. J. 2012, 195, 361-365.
15. *Jaskólska M., Adamiak Z., Zhalniarovich Y., Holak P., Przyborowska P.*: Magnetic resonance protocols in equine lameness examination, used sequences, and interpretation. Pol. Vet. J. 2013, 16, 803-811.
16. *Kofler J., Kneissl S., Malleczek D.*: MRI and CT diagnosis of acute desmopathy of the lateral collateral sesamoidean (navicular) ligament and long-term outcome in a horse. Vet. J. 2007, 174, 410-413.
17. *Murray R. C., Roberts B. L., Schramme M. C., Dyson S. J., Branch M.*: Quantitative evaluation of equine deep digital flexor tendon morphology using magnetic resonance imaging. Vet. Radiol. Ultrasound. 2004, 45, 103-111.
18. *Murray R. C., Schramme M. C., Dyson S. J., Branch M. V., Blunden T. S.*: Magnetic resonance imaging characteristics of the foot in horses with palmar foot pain and control horses. Vet. Radiol. Ultrasound. 2006, 47, 1-16.
19. *Sampson S. N., Schneider R. K., Gavin P. R., Ho C. P., Tucker R. L., Charles E. M.:* Magnetic resonance imaging findings in horses with recent onset navicular syndrome but without radiographic abnormalities. Vet. Radiol. Ultrasound. 2009, 50, 339-346.
20. *Schramme M. C.*: Deep digital flexor tendonopathy in the foot. Equine Vet. Educ. 2011, 23, 403-415.
21. *Schramme M. C.*: Treatment of deep digital flexor tendonitis in the foot. Equine Vet. Edu. 2008, 20, 389-391.
22. *Schramme M. C., Murray R. M., Blunden T. S., Dyson S. J.*: A comparison between magnetic resonance imaging, pathology and radiology in 34 limbs with navicular syndrome and 25 control limbs. Proc. Am. Ass. Equine Pract. 2005, 51, 348-358.
23. *Smith M. R. W., Wright I. M., Smith R. K. W.*: Endoscopic assessment and treatment of lesions of the deep digital flexor tendon in the navicular bursae of 20 lame horses. Equine Vet. J. 2007, 39, 99-102.

Corresponding author: lek. wet. Marta Mieszkowska, ul. Oczapowskiego 14, 10-719 Olsztyn, Poland; e-mail: marta.jaskoolska@gmail.com