

*Strokovni članek*

## ROLE OF THE DIFFERENT RADIOLOGICAL IMAGING MODALITIES IN THE DIAGNOSIS AND STAGING OF EQUINE NAVICULAR SYNDROME. A REVIEW

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### ABSTRACT

Equine navicular syndrome (ENS) is a common ailment responsible for up to one-third of all chronic forelimb lameness. The current presentation, based on literature reviews and veterinary and radiology opinions, offers a brief overview of the current status of imaging the equine navicular syndrome. Conventional radiography, ultrasound, computed tomography, scintigraphy and magnetic resonance imaging are considered since all appear to have some purpose in the diagnosis and staging, relating to the complexity of the syndrome. Appropriate imaging evaluation, following physical examination can yield useful information, not only helping to define the extent of the disease but also facilitating the identification of the most appropriate treatments.

#### **Keywords:**

Radiographic imaging, Equine Navicular Syndrome, Magnetic Resonance Imaging, Computerised Tomography, Ultrasound.

### INTRODUCTION

Equine Navicular Syndrome (ENS) can be responsible for up to one third of all chronic forelimb lameness with a peak incidence at nine years (Turner 1986, Dik et al 2001). It can affect both front and hind limbs and it can be unilateral or bilateral. Morphologically, ENS is characterised by erosion of the palmar fibrocartilage and/or cortex and medullary lysis, fibrillation of the dorsal surface of the flexor digitorum profundus tendon (FDPT), and adhesions between the FDPT and the navicular bone (Thomson et al 1991). However, the significance and nature of these changes is still poorly understood. Many of the ENS associated histological changes have also been noted to resemble those seen in bones close to osteoarthritic joints (Trotter 2001) and include degeneration of the joint cartilage and the development of osteophytes at the bone margins.

The cause of ENS remains unclear and has been linked to hereditary factors (Adams 1974, Ueltschi et al 1995), morphological variability causing joint load and bone stress variations (Fuss et al 1998), poor conformation (Pool et al 1989) and inappropriate shoeing conditions (Wilson et al 2001, Hickman 1989). It has also been suggested that domestication activities such as farriery, training and riding,

fractures of the navicular bone or punctures of the navicular bursa (Adams 1974) and interruption of blood supply to the navicular bone following arteriosclerosis, thrombosis or congestion of key vessels (Leach 1993, May 1997, Astrid et al 1989) have a part to play.

There are no clinical signs that are pathognomic for navicular syndrome and no single test has a predictive value exceeding 53% (Colahan et al 1999), highlighting the difficulties associated with exact clinical diagnoses. The contribution of imaging modalities to medical diagnosis is therefore clear.

The use of radiography for the diagnosis of ENS was first reported in 1934 (De Clerq et al 2000), however since then the role of diagnostic imaging has improved resulting in better diagnoses and improved equine care. Diagnostic modalities such as computerised tomography, magnetic resonance imaging, nuclear medicine and ultrasound, are now used to visualise the navicular bone and associated structures. This helps veterinarians and owners evaluate the effectiveness of therapies in returning a severely lame horse to an athletic career or simply maximising horse comfort (Jurga 1998). The aim of this paper is to provide a brief, up-to-date, review of the ability of imaging modalities to describe the Equine Navicular Syndrome.

### Conventional Radiography

Radiographs are useful to evaluate the structural changes within the ON, yet they do not always correlate with ENS associated lameness. Some horses may be sound with large structural navicular changes, whereas others may be extremely lame with minimum radiographic changes (Voss 1994). Radiographically, bony pathological changes of the navicular bone can be detected: these may include widened, pointed, conical or inverted flask shaped radiolucent channels, cystic lucencies, enthesophytes at the extremities or along the proximal border, chip fragments of the distal border and medullary sclerosis or osteoporosis (Dik et al 2001).

Radiographic images give clear information on calcified elements such as-

- subchondral bone
- marginal osteophytes
- bone nodules
- intra-articular free bodies.

Even with multiple radiographic projections and careful technique, important lesions associated with ENS can often be missed (Widmer et al 2000). Articular capsule, ligaments, synovial fluid and articular cartilage have soft tissue radiographic opacity and often cannot be differentiated from one another. The only soft tissue abnormalities clearly discernible on radiographs are those which induce an increase or decrease in opacity (Denoix et al 1993). This causes difficulty in accurately staging and diagnosing ENS. In addition plain radiography has limited ability to display the early stages of ENS-associated osteo-arthritis and it is only when ENS becomes advanced that these changes are seen radiographically.

For radiographs to be of benefit the radiographs must be of optimal quality with enough projections included in the study to completely evaluate the navicular bone for structural alteration (O'Brien et al 1975)

The four routine radiographic projections are:

1. Dorsoproximal-palmarodistal oblique view (upright pedal view)
2. Dorsoproximal-palmarodistal oblique view (high coronary view)
3. Palmaroproximal-palmarodistal oblique (flexor surface view)
4. Lateral view (lateromedial)

Whilst it is important to always keep radiation dose to the horse to as low as reasonably achievable, for clear bony visualisation slow, high detailed image receptors should be used. Also, as with all imaging procedures, to minimise movement unsharpness, appropriate preparation and restraining devices should be applied.

## Ultrasound (US)

In veterinary radiology of the horse, ultrasound has a number of advantages compared with other modalities including non-usage of ionising radiation, sedation is rarely necessary (equine patient can remain standing) and image production is inexpensive. Due to the mobility and versatility of ultrasound scanners, this modality is readily available, however a skilled operator is required.

Due to the characteristic of ultrasound waves and their inability to visualise bony structures, US has a limited role for visualising the navicular area. Although it is possible to visualise some of the soft tissue structures associated with navicular syndrome such as the FDPT (Whitton et al 1998), other authors insist that diagnostic US is of limited value, because of the poor acoustic window afforded by the palmar aspect of the digit (Widmer et al 2000). To reinforce this point Denoix et al (1993) confirms that the anatomical structure makes evaluating soft tissue structures within the hoof difficult primarily due to the difficulty with positioning the ultrasound probe.

Nonetheless it has been demonstrated that ultrasonography has some diagnostic potential in the detection of the Equine Navicular Syndrome. This includes demonstration of a variety of small fragments within the palmaroproximal aspect of the distal interphalangeal joint, visualisation of calcification of the annular ligament, thickening of the collateral sesamoidean ligament, fragmentation and roughening of the flexor surface and contour of the navicular bone and definition of cystic defects within the navicular bone. It is anticipated that further development of ultrasound will result in greater diagnostic potential in the future (Parks 2001).

## Computerised Tomography (CT) & Magnetic Resonance Imaging (MRI)

Due to logistical problems, diagnostic imaging in equine orthopaedics has been largely limited to radiography, ultrasound, and nuclear medicine. Computerised tomography has been used in horses under general anaesthesia, whereas magnetic resonance imaging has largely been reported in cadaver specimens. Both CT and MRI are widely used in human orthopaedics, but are comparatively new imaging modalities in veterinary medicine. Both rely extensively on computers for image formation and are expensive therefore limiting equine applications to larger institutional practices or human hospitals. Although closed CT and MRI scanners have limited access and necessitate general anaesthesia and recumbent positioning of the horse, open (midfield) MRI scanners facilitate imaging of the equine extremity.

Whilst the two modalities have common advantages such as better visualisation of enlarged synovial fossae and FDPT lesions compared with plain film radiography, each have additional merits.

In contrast to conventional radiography, CT enables cross-sectional slices of limbs to be imaged. Standard CT is limited to slices in a single plane, while spiral CT allows large areas to be imaged rapidly, using data processing, reconstruction in multiple planes as well as 3D reconstructions is possible. Although CT is able to image both bone and soft tissue, compared with MRI, soft tissue contrast particularly relating to tendon damage or adhesions is poor (Whitton et al 1998). Additional authors (Ruohoniemi et al 1999) have found CT to be especially beneficial for the evaluation of complex bone disorders that cannot be properly assessed using conventional radiography. An example of this is the changes that exist in the bone contour of the flexor surface of the navicular bone that are best appreciated with spiral CT. It has been suggested that although conventional radiography remains the primary ENS diagnostic method, CT is recommended in cases where radiographic findings do not support clinical signs (Ruohoniemi et al 1999). In practice the expense of computerised tomography, coupled with its complexity and high radiation dose have limited its use in veterinary surgeries.

Like CT, MRI also provides cross-sectional and 3D images and has revolutionised human orthopaedic imaging. Both bone and soft tissue can be imaged with high contrast and sections can be produced in any plane (Whitton et al 1998). A number of different scanning protocols (sequences) for orthopaedic imaging and a combination of these are often used to highlight different tissues and pathological changes, particularly with excellent demonstration of soft tissues. As veterinary MRI becomes more established within the equine examination a complete examination of all the joint components could be provided thus allowing earlier interventions and treatments particularly relating to intra-articular therapies (Denoix et al 1993). Consequently improvements in visualising thinning and loss of fibrocartilage and navicular bursa effusion will be increasingly evident.

Limitations with MRI should be acknowledged however, and these include reduced sensitivity to changes in bone surface contour compared with radiography or CT (Whitton et al 1998), expense and availability of scanners, difficulty in finding a non-ferromagnetic hoist or table to support the equine patient during the examination for MRI and lack of expertise of veterinarians qualified to operate a scanner. Although limitations with both modalities are evident, advances in technology associated with CT and MRI will in the future, open the market for equipment that allows efficient and economic imaging of the standing equine patient. Undoubtedly, these imaging modalities will play an important role in the evaluation of ENS in the next decade (Widmer et al 2000, Pechman 1999).

## Nuclear Medicine (NM)

Nuclear Medicine demonstrates much promise, particularly in situations where the osseous changes are minimal and undetectable using conventional radiography (Ueltschi et al 1995). Images of the sole of the foot provide visualisation of the navicular bone and the third phalanx. This has led to a number of veterinary hospitals committing to substantial capital investments in order to have effective nuclear scanning devices and storage facilities (Jurga 1998).

Early detection of ENS results in an increased uptake in the navicular area. However, this technique has reduced specificity due to an increase in uptake of the scintillator for a variety of other conditions such as infection, fracture or necrosis of the navicular bone. Also cartilages of the pedal bone can mask uptake in the navicular region. All this means that extra images are required to accurately diagnose the condition and keep the number of false positives to a minimum (Ueltschi et al 1995, Widmer et al 2000). Another difficulty with NM is immobilisation, which is particularly difficult in the case of a horse, however, it is easier to sedate horse for NM (the equine may remain standing) rather than anaesthetise it for CT or MRI.

Notwithstanding the limitations, NM has proven to be a valuable complementary aid in certain conditions such as guiding the interpretation of equivocal radiographic changes, identifying pathological processes before radiographic changes are evident and identifying some processes for which radiographic changes cannot be visualised (Parks 2001). Additionally it can isolate areas of lameness by identifying inflamed and weakened areas of soft tissue and bone, which are not yet radiographically evident and multiple sites can be examined with one diagnostic test.

## CONCLUSIONS

ENS is responsible for a third of lameness in horses (Dik et al 2001). As can be seen from this article, no one imaging modality is a panacea for ENS although MRI has advantages of demonstrating ligaments, tendons and muscles, without using ionising radiation. However currently cost and practicality limit this imaging method at present. Nuclear medicine has shown promising results although care must be taken with image interpretation due to its low specificity. Nevertheless all the imaging modalities have merits and demerits and it is important to remember that each modality has particular uses for providing specific information as outlined in the article.

On a cautionary note none of the imaging modalities are a substitute for careful clinical examination. It is important that radiological imaging modalities provide additional information regarding diagnosis and possible staging of ENS. Its importance can be summarised in the well-known phrase by Williams and Deacon (1999) "No foot no horse" which is as true today as it has always been.

## REFERENCES

- Adams OR. (1974). Lameness in Horses Lea and Febiger, p250
- Astrid DM, Rykenhuisen NF, Dik RJ, Goedgebuure (1989) The Arterial Supply of the Navicular Bone Adult horses with Navicular Disease. *Equine Veterinary Journal* 21(6) 418-424
- Colahan PT, Mayhew IG, Nerript AN, Moore JN (1999). *Equine Medicine Surgery*. 5th ed. London Mosby 513-520
- De Clerq T, Verschooten F, Ysebaert M. (2000). A Comparison of the Palmeroproximal -Palmerodistal View of The Isolated Navicular Bone to Other Views. *Veterinary Radiology & Ultrasound*, vol. 41 (6): 525-533.
- Denoix JM, Crevier N, Roger B, Lebas JF. (1993). Magnetic Resonance Imaging of the Equine Foot. *Veterinary Radiology & Ultrasound*, vol. 34 (6): 405-411.
- Dik KJ, Belt AJM, Brock J. (2001) Relationships of Age & Shape of Navicular Bone to the Development of Navicular Disease: a Radiographical Study. *Equine Veterinary Journal*, 33(2): 172-175.

- Fuss FR, Fuss AH. (1998) Biomechanical Factors for the Etiology of Navicular Syndrome in Sports Horses. Animal Biomechanics Research Group, Vienna Austria on line at <http://www.isbs98.uni-konstanz.de/Abstracts/Franz-Fuss3.pdf> accessed 12th October 2001.
- Hickman J. (1989) Navicular Disease –what are we talking about? *Equine Veterinary Journal* 21 (6) 395-481
- Jurga F. (1998). "Step by Step Navicular Bursography". *The Horse Interactive*, March <[http://www.thehorse.com/0398/step\\_by\\_step.html](http://www.thehorse.com/0398/step_by_step.html)> (19/10/01)
- Leach DH. (1993) Treatment and Pathogenesis of Navicular Disease (syndrome) in Horses. *Equine Veterinary Journal*, 25(6):477-481
- May C (1997). *The Horse Care Manual : How to Keep Your Horse Healthy, Fit and Happy*. London. Stanley and Paul. 153
- O'Brien TR, Millman TM, Pool RR, Sutter PF. (1975). Navicular Disease in the Thoroughbred Horse: A morphologic Investigation Relative to a new Radiographic Projection. *Journal of the American Veterinary Radiology Society*, vol. 16 (2): 39-51
- Parks AH (2001). "The Equine Foot: the relationship between disease, clinical signs, diagnosis and treatment" <<http://www/equipodiatry.com>, The Equine Foot the Relationship Between Disease, clinical signs, diagnosis and treatment> (12/10/01).
- Pechman RD. (1999). "Computed Tomography and Magnetic Resonance Imaging: Emerging Veterinary Imaging Modalities." *Imaging Solutions*. The KVF Jubilee Refresher Course for Veterinarians. Published by Post Graduate Foundation in Veterinary Science, Sydney: 11-17, 23-27.
- Pool RR, Meagher DM, Stover SM. (1989) Pathophysiology of Navicular Syndrome. *Veterinary Clinics of North America. Equine Practice*, vol. 5 (1): 109-129.
- Ruohoniemi M, Tervahartiala P. (1999). Computed Tomographic Evaluation of Finnhorse Cadaver Forefeet with Radiographically Problematic Findings on the Flexor Aspect of the Navicular Bone. *Veterinary Radiology & Ultrasound*, vol. 40 (3): 275-281.
- Thomson KN, Rooney JR, Petrittes-Murphy MB. (1991) On the Pathogenesis of Navicular Disease. *Equine Veterinary Journal*.
- Trotter G. (2001) The Biomechanics of What Really Causes Navicular Disease. *Equine Veterinary Journal*,; 33 (4): 334-336.
- Turner TA. (1986) Shoeing Principles for the Management of Navicular Disease in Horses. *Journal of the American Veterinary Medical Association*, 189(3): 298-301
- Ueltschi G, Honig I, Stomettan D. (1995) Beobachtungen zur Genetik der Podotrochlose Orthopaedie bei Huf und Klauentieren.. Stuttgart : Schattauer, P.F. Knezevic
- Voss ED. (1994) "Heel Lameness – Is it Navicular Disease?" (12/10/01)
- Whitton RC, Buckley C, Donovan T, Wales AD, Dennis R. (1998). The Diagnosis of Lameness association with Distal Limb Pathology in a Horse: A Comparison of Radiography, Computed Tomography and Magnetic Resonance Imaging. *The Veterinary Journal*, vol. 155 (3): 223-229
- Widmer WR, Buckwalter KA, Fessler JF, Hill MA, Vansickle DC, Ivancevich S. (2000). Use of Radiography, Computed Tomography and Magnetic Resonance Imaging for Evaluating Navicular Syndrome in the Horse. *Veterinary Radiology & Ultrasound*, vol. 41 (2): 108-116.
- Wilson A.M. McGuigan M.P. Fouracre L. & MacMahon L. (2001) The force and contact stress on the navicular bone during trot locomotion in sound horses and horses with Navicular disease. *Equine Veterinary Journal*, 33, 159-165.
- Williams G, Deacon M. (1999) *No Foot No Horse. Foot Balance: The Key To Soundness and Performance*. Kenilworth Press Buckingham.