Vet Res Commun (2009) 33:515–520
DOI 10.1007/s11259-008-9197-9

ORIGINAL ARTICLE

Magnetic resonance imaging of the normal bovine digit

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Accepted: 17 December 2008 / Published online: 4 February 2009

Abstract The purpose of this study was defining the normal structures of the digits and hoof in Holstein dairy cattle using Magnetic Resonance Image (MRI). Transverse, Sagital and Dorsoplantar MRI images of three isolated cattle cadaver digits were obtained using Gyroscan T5-NT a magnet of 0.5 Tesla and T1 Weighted sequence. The MRI images were compared to corresponding frozen cross-sections and dissect specimens of the cadaver digits. Relevant anatomical structures were identified and labeled at each level. The MRI images provided anatomical detail of the digits and hoof in Holstein dairy cattle. Transversal images provided excellent depiction of anatomical structures when compared to corresponding frozen cross-sections. The information presented in this paper would serve as an initial reference to the evaluation of MRI images of the digits and hoof in Holstein dairy cattle, that can be used by radiologist, clinicians, surgeon or for research propose in bovine lameness.

Keywords Magnetic resonance image · Bovine · Digit

Introduction

The bovine digit is a complex structure with joints, ligaments and tendons. Current diagnostic imaging technique such as Radiography and Ultrasonograph provide limited information for evaluation of the bovine digits and hoof. Radiography has limited value to

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evaluation of soft tissue, although ultrasonography provides visualization of the tendons and ligaments, however, ultrasonography provides a small field of view and each structure has to be imaged separately, and a cross sectional examination through the entire digit is not possible. Computed Tomography (CT) and MRI appear to be ideal method for examining the digital soft tissue and deep structures for example, Kazer-hotz et al. (1994) and Raji et al. (2008) and appear to be a good tool in bovine lameness researches.

Magnetic resonance imaging is a diagnostic technique that has advanced significantly and it is now routinely used in human medicine for the study and evaluation of anatomy and disease (Goncalves-Ferreira et al. 2001).

In veterinary practice, MRI in small animal is frequently used to evaluate the head (Hundson et al. 1995; Kakhainen et al. 1991; Kraft et al. 1986; Morgan et al. 1993). The use of MRI in large animal medicine is currently limited by logistical problems of acquiring MRI images; meanwhile a few MRI studies on horses' digit have been done for example, Hevesi et al. (2004), Kleitoer et al. (1999) and Murray et al. (2004). Characterization of the normal MRI images of different animals is, however, essential for veterinary radiologists, clinicians and surgeons to interpret these images correctly.

Economic importance of the bovine lameness is completely understood, and many research have been done in this filed for better understanding of the pathogenesis of the bovine hoof and digit problems (Shearer and Van Amstel 2001). In bovine medicine like other large animals logistical problems at the present time, prevent to use the MRI as a diagnostic tool in live animals. But MRI can be used as an excellent tool for investigation of the bovine digit and hoof disease for better understanding of the pathogenesis of the problems and also investigation of the deep structure at the bovine digit in some disease at the normal situation.

The purpose of this study was to provide anatomic reference images of the normal bovine digit using MRI, and gross anatomic sections.

Materials and methods

Nine Holstein dairy cattle hind limbs were obtained from the industrial slaughter house of Mashhad. MRI images of three isolated digits were performed at the Imaging Diagnostic Center, Ghaem hospital, Mashhad, by using Gyroscan T5-NT a magnet of 0.5 Tesla and T1-Weighted sequence by a standard human body coil. Continuous series of transversal, sagital and dorsoplantar scan were obtained from three digit.T1- Weighted MRI images were acquired using the following parameters: repetition time (T_R)=630 ms, echotime(T_E)= 18 ms, 5 mm slice thickness with 1 mm inter slice spacing.

Three digits were fixed in 10% Formalin and dissected after two weeks. Three digits were frozen in −18°C and sectioned in transversal, sagital and dorsoplantar planes in 1-cm slices with an electric band saw and immediately photographed. The frozen sectioned were fixed in 10% formalin for further anatomic dissection. MRI images that most closely matched each gross section were compared to the corresponding gross anatomic section and to text books of anatomy (Getty 1975; Nickle et al. 1995; Popesko 1975).

Results and discussion

One hundred and three MRI images were obtained from digits that were used at present study. Six cross sections photographs with the most closely corresponding MRI images were

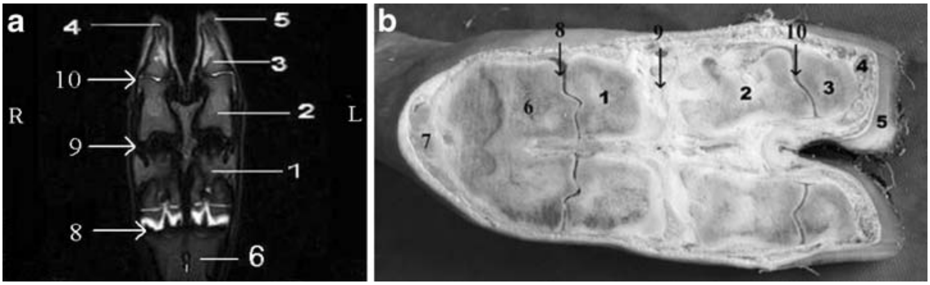

Fig. 1 (a) Dorsoplantar MRI image and (b) gross section at the level of plantar of phalanx. 1, Proximal phalanx; 2, Middle phalanx; 3, Distal phalanx; 4, Corium; 5, Wall of hoof; 6, Metatarsus; 7, Flexors tendon of digit; 8, Metacarpophalangeal joint; 9, Proximal interdigital joint; 10, Distal interdigital join

selected as follows, dorsoplantar (Fig. 1), sagital (Fig. 2) and transversal (Figs. 3, 4 and 5). The transversal MRI images provided excellent depictions of anatomical structures when compared to their corresponding photographs. Identifiable anatomic structure was labeled on the line drawings of the limb sections and on the corresponding MRI images. Structures with bilateral symmetry were only labeled on one side.

MRI images provide excellent anatomic depiction of the bovine digit. In MRI images, cortex of phalanx, fat, skin and hoof were observed and had intermediate signal intensity and appeared grey (Fig. 3). Tendons, blood vessels, synovial cavity and corium of hoof had a hyperintense signal and appeared black (Fig. 2).Medulla of phalanx had a low signal intensity and appeared white (Fig. 1). Proximal, middle and distal phalanx, proximal and distal sesamoid bones, hoof, superficial digital flexor tendon (SDF), deep digital flexor tendon (DDF), extensor branch of interosseous tendon, dew claws, navicular bursa and common dorsal digital artery were clearly identify in MRI images.(Figs. 1–5).

Foot and digit health and lameness are major issues facing dairy producers because of their common occurrence and the tremendous economic losses incurred (Shearer and Hernandez 2000). Early detection and prompt treatment of the problem can minimize the loss, improve recovery, and reduce animal suffering (Shearer and Van Amstel 2001).

MRI is based on the properties of certain elements, mainly hydrogen; to send a radiofrequency signal when it is under a magnetic field of a certain intensity stimulated by

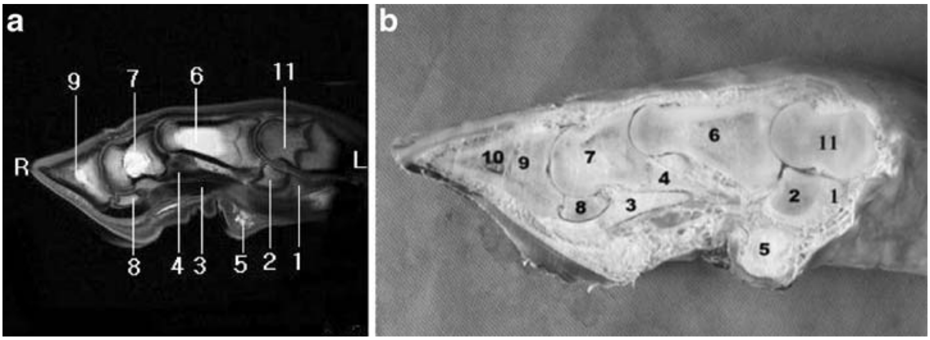

Fig. 2 (a) Sagital MRI image and (b) gross section at the level of distal sesamoid bone. 1, Sesamoid branch of interosseous muscle; 2, Proximal sesamoid bone; 3, Deep digital flexor tendon; 4, Superficial digital flexor tendon; 5, Dew claw; 6, Proximal phalanx; 7, Middle phalanx; 8, Distal sesamoid bone; 9, Distal phalanx; 10, Vessel; 11, Metatarsus

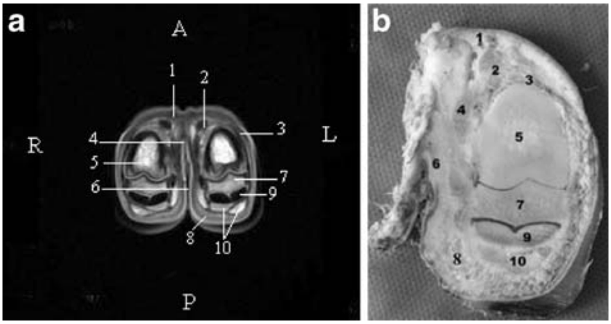

Fig. 3 (a) Transverse MRI image and (b) gross section at the level of distal sesamoid bone. 1, Vessel; 2, Common digital extensor tendon; 3, Lateral digital extensor tendon; 4, Distal interdigital ligament; 5, Middle phalanx; 6, Skin; 7, Distal sesamoid bone; 8, Fat; 9, Deep digital flexor tendon; 10, Sesamoidal ligament

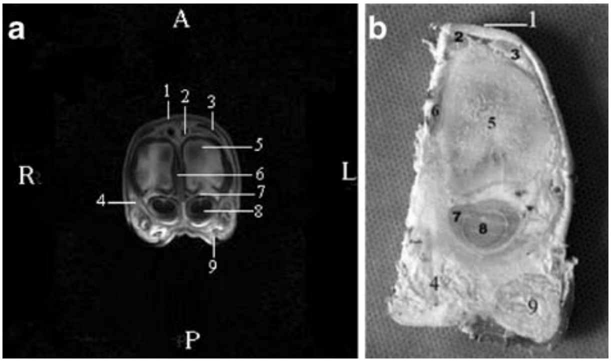

Fig. 4 (a)Transverse MRI image and (b) gross section at the level of Metacarpophalangeal joint. 1, Skin; 2, Common digital extensor tendon; 3, Lateral digital extensor tendon; 4, Fat; 5, Proximal phalanx; 6, Proximal interdigital ligament; 7, Superficial digital flexor tendon; 8, Deep digital flexor tendon; 9, Dew claw

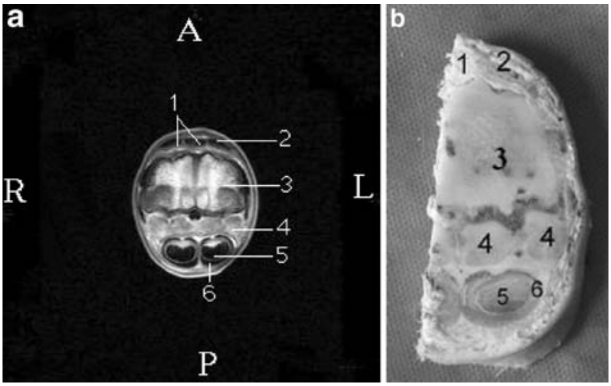

Fig. 5 (a) Transverse MRI image and (b) gross section at the level of proximal sesamoid bone. 1, Common digital extensor tendon; 2, Lateral digital extensor tendon 3, Metatarsus; 4, Proximal sesamoid bone; 5, Deep digital flexor tendon; 6, Superficial digital flexor tendon

radio waves at an appropriate frequency. Advantages of MRI include Multiplan imaging, superior contrast resolution and the absence of ionizing radiation (Shores 1999). So, using MRI in bovine lameness research can open a window of opportunity for better understanding of the pathogenesis of some problems in dairy cattle such as laminitis and some other hoof problems. The corium of the hoof in normal cases at the present study appeared black and very easily identifiable. It means that, with using MRI, probably all stages of the laminitis can be investigate in dairy cattle. This topic needs some more researches. Meanwhile, all the deep structures in the bovine hoof can easily investigate by using MRI.

MRI can not only be used in diagnostic procedures but also can be used in many biometric research, measurements (Onar et al. 2002 and Robina et al. 1991) and experimental (Paulus et al. 2000, 2001). In all of these cases, a normal MRI image is necessary for identifying anatomical structure of the animal.

The use of MRI in bovine medicine is partially limited because of expense the low availability of a suitable unit and a non-magnetic anesthetic unit. Nevertheless, these images should provide useful reference material for further future clinical studies of bovine digit.

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