The Veterinary Journal 233 (2018) 66–75

Contents lists available at ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Original article

Ultrasonography, computed tomography and magnetic resonance imaging of the bovine metacarpo/metatarsophalangeal joint

U. Hagag[a,*], M.G. Tawfiek[b]

[a] Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Beni-Suef University, Beni-Suef 62511, Egypt
[b] Department of Anatomy and Embryology, Faculty of Veterinary Medicine, Beni-Suef University, Beni-Suef 62511, Egypt

ARTICLE INFO

Article history:
Accepted 3 January 2018

Keywords:
Bovine
Computed tomography
Magnetic resonance imaging
Metacarpo/metatarsophalangeal joint
Ultrasonography

ABSTRACT

The aims of the present study were to describe the normal ultrasonographic, magnetic resonance imaging (MRI) and computed tomographic (CT) appearances of the bovine metacarpo/metatarsophalangeal (MCP/MTP) joints and to assess the normal cross-sectional dimensions of the superficial (SDFT) and deep (DDFT) digital flexor tendons. A systematic ultrasound examination was performed on the MCP/MTP joints of 22 healthy cattle and two bovine cadavers, and the cross-sectional dimensions of the SDFT and DDFT were recorded. The cadaveric MCP/MTP joints ($n = 8$) were scanned using a 16-slice multidetector CT scanner and a 1.5 Tesla MRI scanner, injected with green latex and sectioned into transverse ($n = 4$), sagittal ($n = 2$) and dorsal ($n = 2$) slices. Ultrasonographic, CT and MRI images were correlated with corresponding findings in anatomical dissections for the distal aspects of the third and fourth metacarpal/metatarsal bones, proximal aspects of the proximal phalanges, proximal sesamoid bones, lateral, common and medial digital extensor tendons, SDFT, DDFT, axial and abaxial collateral ligaments, suspensory, palmar/plantar, interdigital intersesamoidean and interdigital phalangosesamoidean ligaments, and collateral, cruciate and short sesamoidean ligaments. The axial and collateral sesamoidean ligaments could not be evaluated by ultrasonography. The articular cartilage, and the short and cruciate sesamoidean ligaments, were not identified in CT images. The cross-sectional dimensions of the SDFT and DDFT differed significantly between the forelimbs and hind limbs ($P < 0.05$); there were no significant differences between the contralateral limbs. The annotated ultrasonographic, CT and MRI images are intended as a normal reference that could be useful for interpretation of clinical disease in the bovine MCP/MTP joint.

Introduction

The bovine metacarpo/metatarsophalangeal (MCP/MTP) joint comprises the distal aspects of the third and fourth metacarpal/metatarsal bones, proximal aspects of the corresponding proximal phalanges and two pairs of proximal sesamoid bones (Budras et al., 2011). The joint is reinforced by multiple ligaments and tendons. Ligaments include the axial and abaxial collateral ligaments, suspensory ligament, palmar/plantar ligaments, interdigital intersesamoidean ligaments, collateral sesamoidean ligaments, cruciate sesamoidean ligaments, interdigital phalangosesamoidean ligament and the short sesamoidean ligaments. The MCP/MTP tendons include the lateral digital extensor tendon, medial digital extensor tendon, common digital extensor tendon, superficial digital flexor tendon (SDFT) and the deep digital flexor tendon (DDFT). The MCP/MTP joint has a smaller dorsal recess compared to the larger palmar/plantar recess (Dyce et al., 2010).

Lameness is a significant worldwide problem that has substantial welfare implications and an important economic impact on dairy farms (Solano et al., 2015). The MCP/MTP joint is an important source of lameness (Starke et al., 2006), accounting for 27% of monoarthritis in adult cattle (Meier, 1997). A thorough physical examination is usually performed to diagnose lameness originating from the MCP/MTP joint (Rohde et al., 2000), but can be challenging in cattle with swollen joints (Starke et al., 2007). In such instances, diagnostic imaging modalities, including radiography, ultrasonography, computed tomography (CT) and magnetic resonance imaging (MRI), may improve the likelihood of a definitive diagnosis, with potential benefits for prognosis and treatment in affected cattle (Kofler et al., 2014).

* Corresponding author.
E-mail address: usama.hagag@vet.bsu.edu.eg (U. Hagag).

https://doi.org/10.1016/j.tvjl.2018.01.001
1090-0233/

Radiography and ultrasonography are used for most diagnostic medical imaging in bovine practice (Kofler et al., 2014); ultrasonography is superior for diagnosis of soft tissue disorders, particularly tendonitis and tenosynovitis (Kofler, 2006). Ultrasonographic assessment of tendon injury depends mainly on changes in size and echogenicity. A thorough knowledge of the normal echogenic appearance of the structures examined is important in order to recognise features of injury, to avoid misinterpretation and to prevent false positive diagnoses. The normal ultrasonographic characteristics of the MCP/MTP synovial structures and pouches have been described in cattle (Kofler and Edinger, 1995). The normal cross-sectional dimensions of the SDFT and DDFT have been reported in Nellore and Girolando calves (Gonçalves et al., 2014). However, the normal echogenic features and cross-sectional dimensions of the SDFT and DDFT in adult cattle have not been reported.

CT and MRI have proven valuable for diagnosis of a wide range of musculoskeletal disorders in veterinary practice (Bienert and Stadler, 2006). The main advantages of CT and MRI, compared to radiography and ultrasonography, are three dimensional imaging and concurrent visualisation of bone and soft tissue structures without superimposition (Kraft and Gavin, 2001). The benefits of CT include better bone contrast and a shorter time for examination, while MRI is superior for evaluation of soft tissues and subchondral bone changes (Tucker and Sande, 2001). Concurrently, there is growing interest in the use of CT and MRI in bovine orthopaedics (Nuss et al., 2011) and clinical reports involving CT and MRI have been published (Van Biervliet et al., 2004; Lubbers et al., 2007; Raji et al., 2008, 2009; Becker et al., 2011; Ehlert et al., 2011; Lee et al., 2011; Tsuka et al., 2015; Hagag et al., 2016).

An understanding and knowledge of the descriptive, topographical and cross-sectional features of anatomical structures is necessary for successful diagnostic image interpretation (Latorre and Rodríguez, 2007). The aims of the present study were: (1) to describe the normal ultrasonography, CT and MRI appearances of the bovine MCP/MTP joint; (2) to correlate ultrasonographic, CT and MRI images of the MCP/MTP joint with their corresponding anatomical sections; and (3) to provide the ultrasonographic cross-sectional dimensions of the SDFT and DDFT in adult cattle and assess symmetry between limbs.

Materials and methods

Animals

Ultrasound examination was carried out on the MCP/MTP joints ($n = 88$) of 22 adult healthy non-pregnant Holstein-Friesian cows, with a mean age ± standard deviation (SD) of 7.5 ± 3.3 years and a mean weight ± SD of 498.8 ± 65.0 kg. Animals were confirmed to be free of lameness via locomotion scoring (Sprecher et al., 1997). Ultrasonographic, CT and MRI examinations were carried out on the MCP/MTP joints ($n = 8$) of two fresh cattle cadavers euthanased for reasons unrelated to musculoskeletal disorders. Examinations were carried out within 6 h after euthanasia. The study was approved by the Institutional Animal Care and Use Committee of Beni-Suef University, Egypt (IACUC001/2017; date of approval 3 January 2017).

Ultrasonographic study

Animals were restrained in a chute and the limb to be examined was secured. The MCP/MTP region was clipped, washed with warm water, saturated with 70% alcohol and contact gel was applied. A B-mode ultrasound examination (Eickemeyer Magic 5000 Digital ultrasound machine, Eickemeyer Veterinary Equipment) was carried out using 5–10 MHz linear transducer with a 4–5 cm depth of penetration. The measurement accuracy of the machine was 0.4 mm as per the manufacturers' guidelines.

Ultrasound examination was first performed on standing cows with the examined limb in weight-bearing position. The MCP/MTP joint was imaged from proximal to distal in both transverse and longitudinal planes using dorsal, palmar/plantar, medial and lateral approaches. On the palmar/plantar aspect of the MCP/MTP joint at the apices of the proximal sesamoid bones, two defined distances were measured in the transverse plane via electronic callipers to assess the width (maximum lateromedial borders) and thickness (dorsopalmar/plantar limits) of the DDFT and the thickness (dorsopalmar/plantar limits) of the SDFT (Fig. 6). Measurements were carried out with cows bearing full weight on all limbs. Since the dorsal soft tissues of the MCP/MTP joint were relaxed in the weight-bearing position, complementary longitudinal and transverse imaging of these structures was also performed on the flexed joint with the limb in a non-weight bearing position.

Magnetic resonance imaging study

Limbs were extended and placed with the lateral aspect as the dependent portion and long axis of the limb parallel to the examination table. T1-weighted gradient echo (GRE) images (TR = 1900 ms; TE = 2.74 ms; slice thickness = 3 mm) were obtained in sagittal, dorsal and transverse planes using a 1.5 Tesla magnet (Philips Ingenia 1.5 T, Philips GmbH).

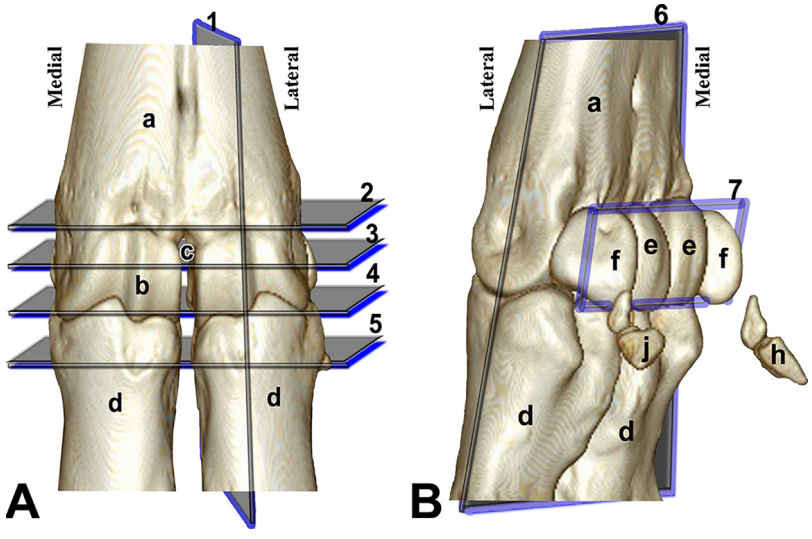

Fig. 1. Three dimensional reconstructed views of the normal bovine metacarpo/metatarsophalangeal joint. Numbered sections indicate the approximate levels of each anatomical slice and the corresponding computed tomography (CT) and magnetic resonance imaging (MRI) depictions. (A) Dorsal view showing the selected sagittal (1) and transverse (2–5) sections. (B) Palmaro/plantarolateral view showing the selected planes for the dorsal (6–7) sections. a, metacarpus/metatarsus; b, sagittal ridge; c, intercapital notch; d, proximal phalanx; e, axial sesamoid bones; f, abaxial sesamoid bones; j, rudimentary digit V; h, rudimentary digit II.