The stifle joint is an important source of lameness in all types of horses.1,2 Because of its clinical importance, anatomically normal stifle joints and stifle joints with pathological changes have been studied extensively via radiography3–5 and ultrasonography.6–10 Radiography and ultrasonography each have limitations for the diagnosis of pathological conditions of the stifle joint, particularly when it involves the structures of the femorotibial joint. Radiography provides information regarding the bony structures, but the diagnosis of soft tissue injury must be inferred by enthesis abnormalities,3 soft tissue swelling, or soft tissue mineralization. Ultrasonography allows evaluation of many soft tissue structures and bone surfaces of the equine stifle joint.9 A complete ultrasonographic examination can be precluded by many factors, including a horse’s temperament, inability to flex the stifle joint, or inability to find an appropriate acoustic window. Inconclusive or incomplete findings on radiography or ultrasonography require clinicians to make a presumptive diagnosis or to use additional diagnostic techniques, such as arthroscopy. Arthroscopy does not allow full investigation of a joint and requires that a horse be anesthetized.11

Magnetic resonance imaging of the anatomically normal equine stifle joint has been described, and use of MRI in some clinical cases has been reported. Although lesions in the menisci and cruciate ligaments have been described, this technique is limited by its

Computed tomographic anatomy of the equine stifle joint

Elke Van der Vekens, DVM; Erik H. J. Bergman, DVM; Katrien Vanderperren, DVM, PhD; Els V. Raes, DVM; Sarah M. Puchalski, DVM; Henri J. J. van Bree, DVM, PhD; Jimmy H. Saunders, DVM, PhD

Objective—To provide a detailed computed tomography (CT) reference of the anatomically normal equine stifle joint.

Sample—16 hind limbs from 8 equine cadavers; no horses had evidence of orthopedic disease of the stifle joints.

Procedures—CT of the stifle joint was performed on 8 hind limbs. In all limbs, CT was also performed after intra-articular injection of 60 mL of contrast material (150 mg of iodine/mL) in the lateral and medial compartments of the femorotibial joint and 80 mL of contrast material in the femoropatellar joint (CT arthrography). Reformatted CT images in the transverse, parasagittal, and dorsal plane were matched with corresponding anatomic slices of the 8 remaining limbs.

Results—The femur, tibia, and patella were clearly visible. The patellar ligaments, common origin of the tendinous portions of the long digital extensor muscle and peroneus tertius muscle, collateral ligaments, tendinous portion of the popliteus muscle, and cranial and caudal cruciate ligaments could also be consistently evaluated. The cruciate ligaments and the meniscotibial ligaments could be completely assessed in the arthrogram sequences. Margins of the meniscofemoral ligament and the lateral and medial femoropatellar ligaments were difficult to visualize on the precontrast and postcontrast images.

Conclusions and Clinical Relevance—CT and CT arthrography were used to accurately identify and characterize osseous and soft tissue structures of the equine stifle joint. This technique may be of value when results from other diagnostic imaging techniques are inconclusive. The images provided will serve as a CT reference for the equine stifle joint. (Am J Vet Res 2011;72:512–)
Computed tomographic arthrography of the stifle joint has been described in 16 clinically affected horses as an additional diagnostic imaging modality for the investigation of stifle joint lameness. Computed tomography and CT arthrography are potentially useful for the evaluation of structures (eg, meniscotibial ligaments, cruciate ligaments, and certain areas of the menisci) that are difficult to evaluate with radiography, ultrasonography, or arthroscopy. Computed tomography or CT arthrography could provide a more complete understanding of pathological conditions of the stifle joint by allowing the simultaneous evaluation of bone and soft tissue structures without superimposition. The disadvantages of CT arthrography include the need for a horse to be anesthetized and the expense, which may largely be offset by the advantages of an accurate diagnosis of the stifle joint lameness.

Reports of arthrography of the equine stifle joint have focused on pathological changes and osseous structures. The use of CT arthrography would allow complete evaluation of several important intracapsular soft tissue structures.

Because of the complexity of the equine stifle joint, a CT anatomy guide that includes standard reconstruction planes is necessary for accurate interpretation of CT images of the stifle joint in patients. The objective of the study reported here was to provide a detailed CT reference of the equine stifle joint via comparison of CT images with gross specimens.

Materials and Methods

Sample—Sixteen hind limbs from 8 equine cadavers were used in the study. Horses were euthanatized for reasons unrelated to the musculoskeletal system by administration of a combination product consisting of embutramide, mebenzoniumiodide, and tetraine (4 to 6 mL/30 kg, IV). Both hind limbs then were disarticulated at the hip joint. In an attempt to ensure the limbs were anatomically normal, the hind limbs were inspected, palpated, and radiographed (lateromedial planes with the long axis of the limb parallel to the CT table). All data were stored. The transverse arthrogram images were reformatted into 0.5-mm-thick sagittal and dorsal slices by use of commercial imaging software.

Anatomic evaluation—Eight hind limbs from 4 equine cadavers (horses ranged from 5 months to 10 years of age) were used in this portion of the study. Each compartment of the stifle joint was punctured with a 16-gauge needle, and synovial fluid (when present) was aspirated. The femoropatellar joint was injected with 60 mL of yellow-colored embedding resin, and the medial compartment of the femorotibial joint was injected with 60 mL of blue-colored embedding resin. The resin became hard within 10 minutes. Limbs were frozen for at least 48 hours at –18°C, and each limb was cut (slice thickness, approx 10 mm) in various planes (sagittal, dorsal, and transverse) with an electric bandsaw. For all limbs, radiography was used to aid in the gross localization of anatomic structures. All anatomic sections were photographed.

CT examination—Eight hind limbs of the 4 other equine cadavers (horses ranged from 5 to 13 years of age) were used in this portion of the study. Similar to the group used for the anatomic evaluation, the 8 hind limbs had a grossly normal appearance, and no abnormal findings were detected during palpation and radiography. The CT examination of the stifle joint was performed within 24 hours after horses were euthanatized. The CT examinations were performed with a 4-detector row spiral CT scanner. The limbs were extended and placed with the lateral aspect as the dependent portion such that investigators could obtain transverse slices with the long axis of the limb parallel to the CT table. After each intra-articular injection of contrast material, the limb was extended and flexed several times to allow for optimal distribution of the contrast material throughout the entire synovial cavity. After injections were completed, the series of arthrogram images was acquired by use of the aforementioned settings.

All data were stored. The transverse arthrogram images were reformatted into 0.5-mm-thick sagittal and dorsal slices by use of commercial imaging software. Transverse, sagittal, and dorsal plane images of all 8 hind limbs were reviewed in a bone window (window width, 2,500 HUs; window level, 800 HUs).

Comparison of CT and anatomic images—Each anatomic tissue section was evaluated with simultaneous evaluation of a corresponding CT image. Anatomic correlation was achieved by comparison of bone and soft tissue contours. The anatomic sections were inspected, and the bony and soft tissue structures were identified with the aid of anatomy textbooks. The bone and soft tissue structures were subsequently located on the corresponding CT images on the basis of shape, size, location, and tissue density characteristics.
Evaluation of CT images—The CT images were used to provide a qualitative description of the femur, tibia, patella, and proximal portion of the fibula as well as the patellar ligaments, collateral ligaments of the femorotibial joint, femoropatellar ligaments, tendinous portions of the long digital extensor muscle and peroneus tertius muscle, cruciate ligaments, meniscotibial ligaments, menisci, meniscofemoral ligament, and regional muscles (gastrocnemius and popliteus muscles). Quantitative data were determined by use of manually drawn regions of interest and were collected for the relative density (in HUs) as measured on precontrast and postcontrast images for several soft tissue structures (ie, patellar ligaments, collateral ligaments of the femorotibial joint, femoropatellar ligaments, tendinous portions of the long digital extensor muscle and peroneus tertius muscle, cruciate ligaments, meniscotibial ligaments, menisci, meniscofemoral ligament, and gastrocnemius and popliteus muscles at the level of the stifle joint).

Statistical analysis—The statistical analysis was performed by use of a statistics software program and used stifle joint as an experimental unit. For comparing 2 measurement sites of the same structure, the Student t-test was used. A 1-way ANOVA, followed by post hoc comparison of means with the Tukey test in case of significance, was used for comparing 3 measurement sites of the same structure. Significance was set at values of \( P < 0.05 \). If the sampling sites of the same structure did not differ significantly from each other, the mean value for the structure was calculated by use of all the values of the different sampling sites.

Results

Eight postcontrast reference CT images were selected as being representative for the main anatomic structures (Figure 1) in conjunction with their corresponding anatomic sections: 3 in a dorsal plane (Figure 2), 2 in a transverse plane (Figure 3), and 3 in a sagittal plane (Figure 4). All CT images were provided in a bone window (window width, 2,500 HUs; window level, 800 HUs).

All bone structures, including the diaphysis of the femur, condyles and trochlear ridges of the femur, extensor fossa, patella, tibial intercondylar eminence, and tibial tuberosity, were seen on transverse, sagittal, and dorsal plane images. All images allowed excellent delineation between the cortex and medulla of the bones, and the trabecular structure was clearly depicted. Sagittal images allowed a detailed evaluation of the contour of the trochlear ridges and both condyles. All stifle joints could be evaluated in detail from the cranial to caudal surface on the dorsal reconstructions.

The term identify was used when a structure could be localized but the image quality was insufficient to...
enable evaluation of its integrity. The term evaluate was used when the shape, size, and attenuation or internal signal of a structure was clearly evident and allowed interpretation of its integrity.

Soft tissue structures that could be evaluated on the various precontrast bone window planes (window width, 2,500 HUs; window length, 800 HUs) included the infrapatellar fat pad, patellar fascia, patellar ligaments, origin of the tendinous portions of the long digital extensor muscle and peroneus tertius muscle, and collateral ligaments of the femorotibial joint. The tendinous portion of the popliteus muscle, cranial and caudal cruciate ligaments, meniscotibial ligaments, and meniscofemoral ligament could be identified but not evaluated on precontrast images. Intra-articular injection of contrast material resolved this problem. The lateral and medial femoropatellar ligaments were not always visible, and intra-articular injection of positive contrast material did not improve visibility of these ligaments.

Extra-articular soft tissues—The extra-articular structures were evaluated on precontrast and postcontrast images. The patellar fascia appeared as a homogeneous zone located dorsal to the patellar ligaments and extending from the dorsal aspect of the patella to the tibia. The infrapatellar fat pad was located between the stratum fibrosum and stratum synoviale of the capsule. This infrapatellar fat pad was located cranial to the proximal portions of the patellar ligaments, caudal to the distal portions of the patellar ligaments, and surrounding the entire intermediate patellar ligament. The infrapatellar fat pad was hypoten- nating relative to the surrounding soft tissue structures; it had a negative HU value and was easily identified on transverse slices and dorsal or sagittal reconstructions (Figure 3).

Patellar ligaments—The proximal and distal aspects of the intermediate patellar ligament appeared as

Figure 2—Photographs of selected dorsal anatomic sections (left) and dorsal reconstructed CT images (by use of a bone window; window width, 2,500 HUs; window level, 800 HUs) obtained after intra-articular administration of positive contrast material (right) of an anatomically normal equine stifte joint. Panels A, B, and C correspond to dorsal CT sections 1, 2, and 3, respectively, in Figure 1. Each image is oriented with the lateral aspect to the left and the proximal aspect to the top. Not all structures appear in each figure. 2 = Lateral compartment of the femorotibial joint, 2b = Subextensor recess, 2c = Caudal recess of the lateral compartment of the femorotibial joint, 3 = Medial compartment of the femorotibial joint, 3a = Medial recess, 3b = Caudal recess of the medial compartment of the femorotibial joint, 4 = Articular cartilage, 6 = Femur, 6a = Lateral femoral condyle, 6b = Medial femoral condyle, 6c = Lateral femoral trochlea, 6d = Medial femoral trochlea, 6e = Extensor recess, 7 = Tibia, 7a = Lateral tibial condyle, 7b = Medial tibial condyle, 7c = Intercondylar eminence, 7c1 = Lateral tibial plateau, 7c2 = Medial tibial plateau, 8 = Fibula, 14 = Lateral meniscus, 14a = Cranial tibial ligament of the lateral meniscus, 14b = Meniscotibial ligament, 15 = Medial meniscus, 15a = Cranial tibial ligament of the medial meniscus, 15b = Caudal tibial ligament of the medial meniscus, 16 = Cranial cruciate ligament, 17 = Caudal cruciate ligament, 18 = Lateral collateral ligament of the femorotibial joint, 19 = Medial collateral ligament of the femorotibial joint, 20 = Common origin of the tendinous portions of the long digital extensor muscle and peroneus tertius muscles, 21 = Long digital extensor muscle, 22 = Lateral digital extensor muscle, 23 = Tendinous portion of the peroneus tertius muscle, 24 = Tibialis cranialis muscle, 25 = Sartorius muscle, 26 = Gracilis muscle, 27a = Vastus lateralis muscle, 27b = Vastus intermedius muscle, 27c = Vastus medialis muscle, 28 = Superficial digital flexor muscle, 29 = Lateral digital flexor muscle, 30 = Medial digital flexor muscle, 31a = Tendon of the popliteus muscle, 31b = Muscle tissue of the popliteus muscle, 32 = Biceps femoris muscle, 35 = Semimembranosus muscle, 36 = Adductor longus muscle, 37a = Lateral head of the gastrocnemius muscle, 37b = Medial head of the gastrocnemius muscle, the caudal tibial ligament of the lateral meniscus does not appear. See Figure 1 for remainder of key.
oval shapes on the transverse images. The intermediate patellar ligament arose from the dorsodistal aspect of the patella and inserted in the groove on the tibial tuberosity. Both the medial and lateral patellar ligaments had a proximal junction with the medial and lateral parapatellar fibrocartilages and inserted distally at the proximal aspects of the medial and lateral ridges of the groove of the tibial tuberosity. The fibrocartilage of the medial patellar ligament was triangularly shaped and hyaline degeneration was responsible for the hypodense line of fat visible at the distal insertion of the patellar ligament (or even along its entire length in some stifle joints). Proceeding distally, the caudal part of the ligament attached on the proximodistal aspect of the lateral ridge of the groove of the tibial tuberosity, whereas the cranial part inserted on the cranial aspect of the lateral ridge of the groove of the tibial tuberosity at the same level as the insertion for the medial patellar ligament. All patellar ligaments were clearly seen on all reconstructions (Figures 3 and 4), but a dorsal reconstruction that included the 3 patellar ligaments in their entirety was not possible. The patellar ligaments were homogeneous in density, except for their most distal parts, where hypodense linear structures were seen mainly in the deep aspect of all 3 ligaments. Fat was found macroscopically in the distal aspect of all 3 patellar ligaments in our study and was confirmed histologically (unpublished data).

The junctions of the lateral and medial femoropatellar ligaments with the patella were located at the proximolateral and proximomedial aspects of the patella, respectively. They were oriented in a cranioproximal-caudodistal direction and inserted on the lateral and medial femoral epicondyle, respectively, proximal to the respective ipsilateral collateral ligament of the femorotibial joint. Both femoropatellar ligaments had a primarily ovoid shape but were extremely difficult to delineate.

The median septum, which represented the axial aspects of the joint capsules of the medial and lateral compartments of the femorotibial joint, could best be identified on both the transverse and dorsal reconstructions. It was homogeneous and hypoattenuating, compared with the collateral ligaments of the femorotibial joint.

For the femoropatellar joint, the suprapatellar recess could be evaluated as well as the lateral and medial recesses located at the abaxial aspects of the lateral and medial femoral trochlea. The most distal extension of the femoropatellar joint could be seen at the level of the intercondylar eminence of the tibia. The lateral compartment of the femorotibial joint contained 3 recesses. The subextensor recess was visualized surrounding the tendinous portions of the long digital extensor muscle and peroneus tertius muscle (Figure 2). The cranial recess of the lateral compartment of the femorotibial joint was located cranial to the lateral tibial tubercle and the axial aspect of the medial tibial plateau of the intercondylar eminence (Figure 3). The caudal recesses of the lateral and medial compartments of the femorotibial joint were seen caudal and proximal to the lateral and medial femoral condyles, respectively (Figure 4). The medial recess of the medial compartment of the femorotibial joint was visualized cranial and abaxial to the medial tibial plateau of the intercondylar eminence and extended between the medial patellar ligament and the medial collateral ligament of the femorotibial joint.

Capsular and intracapsular ligaments—All intracapsular ligaments appeared homogeneous in density. The lateral and medial collateral ligaments of the femorotibial joint were best seen on transverse and dorsal images (Figures 2 and 3). The medial collateral ligament attached proximally at the medial femoral epicondyle and inserted on the medial condyle
of the tibia; it ran perpendicular to the proximal articular surface of the tibia (tibial plateau). The lateral collateral ligament began at the indentation proximal to the lateral femoral epicondyle and ran obliquely in a slight caudodistal direction and inserted with its major branch on the head of the fibula and with its minor branch on the proximolateral aspect of the lateral tibial condyle.

The proximal attachment of the cranial cruciate ligament was the axial aspect of the lateral femoral condyle, and the distal attachment was on the cranial intercondylar area of the tibia at the cranial aspect of the medial tubercle of the intercondylar eminence of the tibia immediately proximal to the cranial tibial ligament of the lateral meniscus. It was oriented in a craniodistomedial direction. The cranial cruciate ligament could be followed from its proximal to its distal attachment on transverse images, but it was best identified on oblique parasagittal images oriented in a craniodistomedial direction. The cranial cruciate ligament was only clearly identified on the arthrogram images (Figure 4).

The caudal cruciate ligament was oriented in a caudodistal direction starting at the medial aspect of the intercondylar fossa of the femur and inserting on the popliteal notch of the tibia. Similar to the cranial cruciate ligament, the caudal cruciate ligament could be followed from its proximal to its distal attachment on transverse images, but it was best identified on a sagittal image oriented in a caudodistal direction. The caudal cruciate ligament was more clearly identified on the arthrogram images than on the precontrast CT images (Figure 4).

The lateral and medial menisci were semilunar structures; the lateral meniscus was located between the lateral femoral condyle and lateral tibial condyle, and the medial meniscus was located between the medial femoral condyle and medial tibial condyle. The lateral and medial menisci were attached to the tibia via the meniscotibial ligaments. The cranial tibial ligament of the lateral meniscus inserted on the cranial intercondylar area of the tibia at the axial aspect of the medial tubercle of the intercondylar eminence, whereas the cranial tibial ligament of the medial meniscus inserted on the cranial intercondylar area of the tibia at the abaxial aspect of the medial tubercle of the intercondylar eminence. The caudal pole of the lateral meniscus was attached to the popliteal notch of the tibia by the caudal tibial ligament of the lateral meniscus, and it had a second ligament oriented in a proximomedial direction, with a junction on the axial aspect of the medial femoral condyle (caudal to the origin of the cranial cruciate ligament) that represented the meniscofemoral ligament. The caudal pole of the medial meniscus was attached to the cranial intercondylar area of the tibia by the cranial tibial ligament of the medial meniscus and the caudal meniscus to the cranial aspect of the medial tubercle of the intercondylar eminence. Depending on the area of interest within the meniscus, the...
The tendinous portion of the long digital extensor muscle and tendinous portion of the peroneus tertius muscle had a common origin from the extensor fossa on the femur. The tendinous fibers of the peroneus tertius muscle were located medial to those of the long digital extensor muscle and remained fibrous throughout their entire length. At the proximal border of the tibia, the peroneus tertius muscle occupied two-thirds of the tenosynovial structure, and the tendinous portion of the long digital extensor muscle occupied one-third. This level is anatomically described as the extensor sulcus of the tibia. More distally, the muscular portion of the long digital extensor muscle developed, which was located cranial to the peroneus tertius muscle and was hypodense, compared with the tendinous part. Dorsal and transverse planes allowed optimal evaluation of these structures (Figures 2 and 3).

Quantitative measures of the relative density of various structures were summarized (Table 1). The postcontrast measurements were not reliable.

### Table 1—Mean ± SEM number of HUs for various structures measured in various segments of the equine stifle joint (n = 7 joints).

<table>
<thead>
<tr>
<th>Structure</th>
<th>Segment†</th>
<th>Mean ± SEM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patellar ligaments</td>
<td>Cranial</td>
<td>ND</td>
</tr>
<tr>
<td>Lateral</td>
<td>Caudal</td>
<td>ND</td>
</tr>
<tr>
<td>Proximal</td>
<td>Distal</td>
<td>ND</td>
</tr>
<tr>
<td>Cartilage§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTE&amp;P</td>
<td>Cranial</td>
<td>ND</td>
</tr>
<tr>
<td>Level of origin</td>
<td>Caudal</td>
<td>ND</td>
</tr>
<tr>
<td>Level of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>extensor sulcus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cruciate ligaments</td>
<td>Cranial</td>
<td>ND</td>
</tr>
<tr>
<td>Caudal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fascia¶</td>
<td>Cranial</td>
<td>ND</td>
</tr>
<tr>
<td>IPF</td>
<td>Caudal</td>
<td>ND</td>
</tr>
<tr>
<td>Median septum#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscles**</td>
<td>Cranial</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Caudal</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Proximal</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Distal</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Cartilage§</td>
<td></td>
</tr>
</tbody>
</table>

*When there was no significant (P < 0.05) difference among the various segments of a structure or corresponding structures, the mean ± SEM value is reported. †Segments of structures; division into segments was not identical for all structures. ‡Middle between cranial and caudal or between proximal and distal. §Cartilaginous part of the MPL. ¶Fascia at the cranial aspect of the stifle joint. #Median septum between the lateral and medial compartments of the femorotibial joint. **Peroneus muscle and lateral head of the gastrocnemius muscle, where evaluated.

CLFTJ = Collateral ligament of the femorotibial joint. CTE&P = Common origin of the tendinous portions of the long digital extensor muscle and peroneus tertius muscle. PFL = Lateral patellar ligament. IPL = Intermediate patellar ligament. LPL = Lateral meniscotibial ligament. MPL = Medial patellar ligament. MTLs = Meniscotibial ligaments. NA = Not applicable for this structure. ND = Not determined. NR = Not reported.

### Discussion

In the study reported here, we provided reference CT and CT arthrogram images with corresponding anatomic cross sections in addition to a qualitative description of the osseous, extracapsular, capsular, and intracapsular soft tissues of the equine stifl joint. The images provided should augment the clinical use of CT for the diagnosis of pathological conditions within the stifle joint that result in clinical lameness.

Computed tomography of the equine stifl joint has shown promise as a clinically useful technique for the diagnosis of stifl joint injuries. Injuries of the meniscus, cranial tibial ligaments of the lateral and medial meniscus, and cruciate ligaments have been identified and characterized. It is difficult or even impossible to delineate or interpret injuries affecting these structures by the use of other imaging modalities. Critical to the use of CT is the high image quality with the ability to re-
solve and identify small clinically important structures of the stifle joint. In the present study, images were obtained with a multirow detector spiral CT, which has substantially better conspicuity of small structures, compared with that of conventional axial CT. Improvements are attributed to the thinner collimation, faster scanning, higher spatial resolution, decrease in noise, and larger number of images generated during the same scanning time. Use of bone windows, particularly after intra-articular administration of contrast material, was superior to use of soft tissue windows for identification and evaluation of all structures. For this reason, soft tissue windows were not used.

To our knowledge, the study reported here provides the first anatomic description of the equine stifle joint via CT and CT arthrography in which the bony structures were clearly identified, as were the most clinically important soft tissue structures. This is consistent with reports of CT arthrography in other species, such as the stifle joint of dogs and the knee of humans. Other reports of arthrography of the equine stifle joint have focused on pathological changes and osseous structures.

In humans, MRI is commonly used to assist in the diagnosis of acute soft tissue injury of the knee. Magnetic resonance imaging is noninvasive, does not use ionizing radiation to generate images, and has a higher soft tissue resolution than for CT. Magnetic resonance imaging of the equine stifle joint has been described for clinical patients, but this is only available in a few practices for adult horses. However, CT has several advantages over MRI, such as a shorter examination time, wider availability, and low susceptibility to and limited number of artifacts related to microscopic metallic debris. In addition, the purchase and maintenance costs for CT are lower than those for MRI. In humans, sensitivity and specificity of CT arthrography are similar to those of MRI for the evaluation of menisci and cruciate ligaments, and CT arthrography is preferred in patients with chronic knee pain or suspected cartilaginous, meniscal, or chronic cranial cruciate ligament lesions. Also, CT arthrography can be performed on humans who do not fit into an MRI machine because of obesity or extremely large body habitus. Intra-articular injection of positive contrast material is required to allow for a complete examination of the soft tissues of the stifle joint in horses, especially for evaluation of the integrity of clinically important structures such as menisci, meniscotibial ligaments, and cruciate ligaments. In this study, ultrasound guidance was used to ensure accurate placement of the contrast material into the appropriate synovial structure. This was easily performed with a routinely available linear probe. Nonionic contrast material was used and is recommended because ionic and older nonionic contrast agents can induce transient chemical synovitis. Other complications (eg, infection) associated with arthrography are rare.

As performed in the present study, CT arthrography allowed complete evaluation of several important intracapsular soft tissue structures. The cranial and caudal cruciate ligaments could be evaluated in their entirety with regard to size, shape, margins, and homogeneity. Although ultrasonography can be used to evaluate the cruciate ligaments, its use is dependent on an appropriate acoustic window and requires an experienced ultrasonographer. Furthermore, ultrasonography lacks completeness; therefore, there is inherent difficulty in accurately diagnosing injuries to the stifle joint by the use of ultrasonography. In humans, CT arthrography represents a valuable alternative to MRI for examination of patients with knee disorders. In addition to the cruciate ligaments, the meniscotibial ligaments and menisci were visible in their entirety with CT arthrography. Abnormalities of the meniscotibial ligaments and menisci have been described in dogs and horses by the use of CT arthrography. Even with the use of multiplanar reconstruction, it was not possible to include all of the meniscotibial ligaments on a single image, probably because of the orientation of these ligaments and the orientations of both tibial condyles. Ultrasonography is commonly used to evaluate the surface and internal structure of most parts of the menisci. Arthroscopy allows direct evaluation of the meniscal surfaces, but only the most cranial aspects can be evaluated by use of a standard approach, and certain important lesions (eg, horizontal tears) can be missed. The cruciate ligaments and parts of the meniscotibial ligaments cannot be evaluated completely via arthroscopy because of their extra-articular location. Use of CT arthrography allows clear evaluation of the integrity of the surfaces of the menisci and the internal structure of the menisci. Although CT arthrography allowed complete evaluation of several important soft tissue structures, retrospective studies of clinical cases are necessary to determine the sensitivity and specificity of this modality for diagnosis of various lesions.

Communication between the femoropatellar joint and medial compartment of the femorotibial joint has been detected in 85% of horses, whereas communication between the femoropatellar joint and the lateral compartment of the femorotibial joint has been detected in 20% of horses, and communication between the femoropatellar joint and both compartments of the femorotibial joint has been described in 5% of horses. In the study reported here, a communication between the femoropatellar joint and the medial compartment of the femorotibial joint was observed in only 1 stifle joint. The difficulty in imaging and delineating the femoropatellar ligaments in the present study can be explained by their small size and oblique orientation. The visualization of these structures was not improved on multiplanar reconstructions.

Postcontrast HU measurements were highly variable with regard to the numeric values; therefore, only the precontrast HU values were reported in this study. The variations in HU values for the postcontrast measurements were most likely attributable to beam-hardening artifacts. Therefore, the authors recommend the use of precontrast density measurements. The HU values in the present study were similar to those reported in another study.

A limitation of the present study is that the limbs used for the CT examination and the anatomic images were not from the same horses. Injecting the joints with contrast material for the CT examination and storing
the limbs as fresh specimens precluded use of the same anatomic specimens for injection with colored resin and freezing. In the anatomic sections in the parasagittal planes, immature horses were used. This was evident in the physical cartilages and a more reddish appearance of the bone marrow in the images from those horses. Mature horses were used to obtain the CT images, which caused a discrepancy between the anatomic and CT images. All of the soft tissue structures were detected at the same location in both immature and mature horses. Although the same volume of pigmented resin and contrast material was used for both the anatomic sections and CT examinations, some variation was evident in the degree of distention of the joint recesses between corresponding anatomic and CT images. Attempts should be made to disperse the contrast material as equally as possible by multiple flexions of the joint. However, variation in distention of the recesses did not influence our ability to see the structures of interest.

We concluded that CT and CT arthrography of the stifle joint are valuable techniques for use in evaluating bony and intracapsular and extra-articular structures of the equine stifle joint. Both CT and CT arthrography can be of great value when results of radiography and ultrasonography are inconclusive or when used to define the extent of lesions. In addition, CT and CT arthrography are more widely available and have fewer technical limitations than does MRI, and they offer a less invasive alternative to arthroscopy of the stifle joint. Computed tomography and CT arthrography are techniques that allow complete and direct evaluation of the cruciate ligaments, menisci, and meniscotibial ligaments. The images provided in this study can serve as a CT reference of the equine stifle joint.

References


