Fluid collection within the synovial sheath of the tendon of the flexor hallus longus muscle in the tarsal joint of rats: an anatomic variant detectable with magnetic resonance imaging

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Summary
Magnetic resonance (MR) images of the right tarsal joint of 22 normal male Han:Wistar rats were acquired using a 4.7 T magnet. An intermediate–high signal area associated with the tendon of the flexor hallus longus muscle was noticed in three rats on T2-weighted images. These areas appeared as an intermediate–high signal on lightly T2-weighted images, but appeared as an iso-signal to muscle structure on proton density weighted images. Histology preparations showed that such areas were caused by a sizable fluid collection within the synovial sheath of the tendon of the flexor hallus longus muscle, with all other joint structures appearing normal. This anatomic variant could be potentially regarded as a lesion on T2-weighted MR images, such as inflamed tissue with oedema, especially when the spatial resolution and/or signal-to-noise ratio are not optimal.

Keywords  Rat; tarsal joint; synovial sheath; magnetic resonance imaging

High-resolution computerized tomography (CT) and magnetic resonance (MR) imaging have been extensively used in the research of laboratory animal joint disease models, allowing non-invasive tracking of the disease, monitoring its progress and response to potential treatment (Beckmann et al. 1995, Kapadia et al. 1998, Jacobson et al. 1999). CT and MR imaging of joints have also been used for veterinary care, both for the assessment of joint function and diagnosis of joint pathologies (Snaps et al. 1998, Reichle & Snaps 1999, Widmer et al. 2000, Gielen et al. 2001, 2002). CT and MR imaging surpass conventional radiological methods for joint diseases imaging, facilitating earlier and more accurate diagnosis.

Recently, we had the opportunity to assess the right tarsal joint of normal rats by MR imaging. These MR scans were carried out to establish baseline anatomical information for further pharmacological studies on these rats. Here we report the findings of an anatomic variant in the tarsal joints of rats, which could potentially lead to mis-diagnosis.

Materials and methods
There were 22 male Han:Wistar rats (supplier: Charles River, UK), aged 11–12 weeks. Animals were multiple-housed three/cage in standard conditions. Water from the site drinking water supply and food (R&M No. 1, SQC, pelleted diet, supplied by Special Diets Service Ltd, England) were freely available. These animals were thoroughly examined after arrival to our
facility. Thereafter, the animals underwent a thorough daily clinical examination, including body weight, physical condition and behaviour, no abnormality was found in any of the animals.

The MR scanner was a 4.7-T Varian horizontal MR system (Varian Inc, Palo Alto, CA, USA) equipped with a gradient of 200 mT/m (Oxford Instruments, Oxford, UK). The radiofrequency coil was an in-house-built single-turn solenoid RF coil (for its principle, see Fan et al. 1987), 15 mm in diameter and 25 mm in length.

Animals were lightly anaesthetized with 1.5–1.7% isofluorane (Abbott Laboratories, Kent, UK), which was supplied in the magnet via a facemask. Respiration rate was monitored continuously during imaging using a signal transducer/amplifier linked to a water-filled balloon placed under the abdomen of the animals. The respiration rate was considered to be an indicator of the depth of anaesthesia. Temperature of the animals was monitored continuously by rectal probe and maintained at 38 ± 0.1°C by a continuous flow of heated air. All work was performed in full compliance with licenses issued under the UK Animals (Scientific Procedures) Act, 1986.

MR imaging included a multi-slice spin echo sagittal proton density weighted scan (time of repetition [TR]/time of echo [TE] = 1.000/0.009 s) and a lightly T2-weighted scan (TR/TE = 1.000/0.030 s). The slice thickness was 0.65 mm, and the

Figure 1 Normal MRI sagittal view of the right tarsal joint of the rat. The upper row shows T2-weighted images, and the lower row proton-weighted images. C: calcaneus; Ta: talus; Ti: tibia; white arrow: flexor hallucis longus muscle.
in-plane resolution was 78 μm × 156 μm for both sequences. The right tarsal joint of rats was chosen to be scanned for convenience due to the set-up of the radiofrequency coil. The left tarsal joint was not scanned due to consideration of the anaesthesia duration.

For histology, the tarsal joints were fixed as a whole in 10% buffered formalin, and subsequently decalcified in 10% formic acid solution. Samples were processed by standard histological techniques to wax blocks and multiple longitudinal step sections cut and stained with haematoxylin and eosin.

Results and discussion

High-resolution MR images of the right tarsal joint of rats were obtained with good signal-to-noise ratio (Figure 1). The muscles showed an intermediate-grey signal. The tendon, fibrous bands, bone cortex and bone trabeculae showed a dark signal. The fat pad and fatty tissue in bone marrow showed a bright signal.

In addition to various anatomical structures as normally expected to be seen on tomographic images in a tarsal joint, an intermediate-high signal area associated with the tendon of the flexor hallus longus muscle was noticed in three rats on T2-weighted images (Figures 2 and 3), and in one rat it was quite sizable (Figure 3). These areas appeared as an intermediate-high signal on lightly T2-weighted images, but appeared as an iso-signal to muscle structure on proton density weighted images, and therefore became invisible. Although these areas had a well-defined border in some sections, they

![Figure 2](https://example.com/figure2.png)

**Figure 2** MRI sagittal views of the right tarsal joint of the rat. T2-weighted image (A) and proton-weighted image (B). (A) and (B) are the same sections. An intermediate-high signal area on T2-weighted image (white dashed arrow) is attached to the lower end of the flexor hallus longus muscle (white arrow). This area appears nearly as an iso-signal to the muscle on the proton density weighted image.
could be ill-defined due to ‘partial volume effect’ (Figure 3).

To clarify the MRI findings, the rats with the described MRI findings were killed for histology. Histology showed that such areas were caused by a sizable fluid collection within the synovial sheath of the tendon of the flexor hallus longus muscle (Figure 4). All other structures of the tarsal joint appeared normal.

Usually there is very little fluid within the synovial sheath of the tendon of the flexor hallus longus muscle in the tarsal joints of rats, and would not be expected to be seen on MR images (Figure 1). However, as shown with our results, fluid collection within the synovial sheath of the tendon of the flexor hallus longus muscle in the tarsal joint of rats can occasionally be sizable enough to be detected by MR imaging. This anatomic variant should be correctly recognized by biomedical researchers as well as veterinary practitioners who use modern imaging tools to study rat tarsal joints. Otherwise, it could be potentially regarded as a lesion, such as inflamed tissue with oedema.

When micro-CT is used for examination of the rat tarsal joint, this fluid collection would appear low density; so the possibility of mis-diagnosis also exists with this technique.

To our knowledge, there is no imaging literature report on this anatomical phenomenon in rats. However, a similar finding has been described in humans (Stoller & Ferkel 1997). Recognizing this anatomical phenomenon would help correct image reading during experimental interpretation.
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References


Kapadia RD, Stroup GB, Badger AM, et al. (1998) Applications of micro-CT and MR microscopy to study pre-clinical models of osteoporosis and osteoarthritis. Technology and Health Care 6, 361–72


