P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.186

Low-Grade Osteoarthritis T2-Relaxation Map Values on *Ovis aries* Stifle Joint: An *Ex-vivo* Study

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Article History: 24-440 Received: 15-Mar-24 Revised: 19-May-24 Accepted: 21-May-24 Online First: 06-Jun-24

ABSTRACT

The ovine stifle joint is one of the most studied animal models and is highly similar to the human knee joint. Early knee osteoarthritis (KOA) is challenging to assess with conventional radiography. The magnetic resonance imaging (MRI) T2-map technique can assess cartilage at the subcellular level before alterations in the cartilage surface occur. However, no studies have evaluated the T2-map values for the ovine osteoarthritis (OA) model. A total of 6 *ovis aries* "sheep" that underwent total lateral meniscectomy of the right hind limb and two control groups were sacrificed in the animal laboratory after 12 weeks of surgery. Then, the stifle joints were transported to the MRI facility in a cool box with a temperature between 2-4ºC and subjected to a 3.0 Tesla MRI with a cartigram protocol. The imaging was divided into three compartments (cranial, medial, and lateral). Comparisons with standard negative control were recorded and analyzed. The standard T2-relaxation time for the negative control "sheep" in the lateral vs. medial vs. cranial compartment was (51.5±9.18ms vs. 45.57±3.67ms vs. 54.88±1.56ms; P=0.785). A significantly (P=0.024) different mean T2-relaxation time was found in the OA stifle joint with lateral compartment vs. medial and cranial (68.24±20.26ms vs. 45.57±3.67ms vs. 55.59±5.34ms). MRI T2-mapping evaluation can detect relaxation time changes in sheep's distal femoral, proximal tibia, and patellar cartilages with low-grade OA. The normal sheep T2 relaxation time ranges from 45.57–54.88ms, while the low-grade OA sheep T2 relaxation time ranges from 45.57–88.50ms throughout compartments, with the indexed compartment significantly showing the highest T2 relaxation time. This study has the potential to function as a dependable source to track changes in OA progression and to evaluate the effectiveness of potential therapeutic agents in sheep and as a model in humans.

Keywords: MRI 3.0 Tesla, T2-map, Low-grade Osteoarthritis, Post-meniscectomy, *Ovis aries*

INTRODUCTION

Osteoarthritis of the knee (KOA) is one of the most common degenerative diseases in the veterinary field that has a significant impact due to pain, reduced function, and lameness, which could cause socio-economic problems (Primorac et al. 2020; Sen and Hurley 2023). Early intervention in the early stage is vital for minimizing its progression, as damage to the cartilage can be limited or stopped (Buckwalter 2002). Hence, it is crucial to have various courses of action to diagnose KOA as soon as possible.

In practice, physicians can diagnose osteoarthritis (OA) using physical examination and digital radiography. However, both physical OA findings in examination and digital radiography can't evaluate cartilage defects in early OA (Zhao et al. 2022). Although ultrasonography (USG) has the potential for diagnosing OA, its accuracy depends

Cite This Article as: Pontoh LA, Fiolin J, Priosoeryanto BP, Halim K, Dilogo IH and Hardiman JA, 2024. Low-grade osteoarthritis T2-relaxation map values on *Ovis aries* stifle joint: an *Ex-vivo* study. International Journal of Veterinary Science x(x): xxxx. https://doi.org/10.47278/journal.ijvs/2024.186

on the user and may not always align with macroscopic pathological changes. Additionally, it cannot identify the weight-bearing articular surface (Seidler et al. 2023). Computed tomography (CT) is able to evaluate periarticular and articular tissue. However, the complex intra-articular structure of the synovial joint may hinder the evaluation due to the blurring of the details. Diagnostic arthroscopy, while highly sensitive in visualizing the cartilage surface, it is invasive and may not allow for complete joint exploration due to joint distraction limitations (Seidler et al. 2023). Nowadays, Magnetic Resonance Imaging (MRI) has been defined as the golden standard for diagnosing and evaluating the severity of OA (Zhao et al. 2022; Chung et al. 2023).

MRI has an excellent soft-tissue contrast. Thus, MRI can provide details regarding cartilage structure and thickness (Gold et al. 2009). Currently, MRI is the best imaging technique available to assess changes in the articular cartilage (Gold et al. 2009). Imaging the damaged cartilage regions may provide morphologic information, such as assessing partial or full-thickness cartilage damage or fissuring on the cartilage. Besides morphologic assessment, MRI can also provide information regarding biochemical and physiologic changes in the cartilage tissue (Recht et al. 2005; Gold et al. 2009). However, there have been limitations in the visualization of cartilage in the veterinary field, mainly due to the size of the cartilage visualized. These limitations have been partially overcome by new quantitative techniques like T2 mapping.

Recent MRI T2 mapping techniques can evaluate the physiological properties of cartilage, including assessment of cartilage matrix components, and allow precise localization of signal changes non-invasively. MRI T2 mapping, or T2 relaxation time mapping, assesses the time of water molecule excitation and relaxation back to its previous state (Recht et al. 2005; Gold et al. 2009). Physiological or healthy cartilage contains an organized type 2 collagen framework associated with water molecules. Disruption of cartilage matrix and collagen fibers in the damaged cartilage leads to increased water content due to alteration in water molecules' interaction with proteoglycan and collagen matrix. Hence, an increase in T2 relaxation time mapping was observed in damaged cartilage, improving sensitivity for detecting lesions within the cartilage matrix (Recht et al. 2005; Chou et al. 2008).

Several studies have evaluated MRI T2 mapping in large animal models, including the goat, horse, and sheep (Toth et al. 2017; Pownder et al. 2018; Bunzendahl et al. 2023; Baker et al. 2022). To date, no study has evaluated MRI T2-map values in large animal studies, such as in sheep with low-grade OA. The sheep stifle joint shares similarities in size, viscoelasticity, and topography with the human knee joint. Overall, the sheep stifle joint exhibits a structure comparable to the human knee joint (Burger et al. 2007; Oláh et al. 2019). Although we can reduce the need for animal models, we cannot eliminate the need for preclinical research. This study marks the world's first attempt to observe changes in the stifle joint using MRI T2 mapping in a sheep OA model. The primary objective of this study is to monitor changes in the sheep's stifle joint post-meniscectomy through MRI T2 mapping.

MATERIALS AND METHODS

The Faculty of Medicine Universitas Indonesia approved all of the study designs and procedures with clearance number (KET-932/UN2.F1/ETIK/PPM.00.02/2022) and by the School of Veterinary Medicine and Biomedical Sciences for Animal Care and Use Committee (ACUC) number 023/KEH/SKE/IX/2022. A total of 8 *Ovis aries* sheep from a local breeder with a complete vaccination certificate from the health city ministry was included in this study. Prior to the surgery, a veterinarian from the same local institution performed a complete physical and laboratory examination. The sheep were divided into four paddocks, with two in each, equipped with stone yards for resting. They were provided with concentrate, hay, and mineral salt and had access to water from man-made drinking troughs. Before any medical procedures requiring surgery, anesthesia was administered to alleviate any discomfort experienced by the animals. As described in the previous study, one veterinarian performed a total lateral meniscectomy on six sheep with anesthesia (Fiolin et al. 2024). Total lateral meniscectomy was performed on the right hind limb of the sheep and evaluated daily. After 14 days of monitoring, we remove the surgical suture. Two sheep that did not undergo total lateral meniscectomy served as the control group. Inclusion criteria were male with a body weight of 25-30kg, three years old, and skeletally mature. The exclusion criteria were sheep with muscle and joint injury or prior injury to the right hind limb.

After 12 weeks, the sheep were euthanized in a cage approximately 40km (2 hours drive) from the MRI center. Immediately after euthanized, the 7.5cm proximal and distal stifle joint was exposed and freed from surrounding soft tissue, then wrapped using cling wrap and put inside a thin wall before being stored in the cool box with a temperature maintained between 2-6ºC. The cool box was transported no later than 2 hours, and the stifle joint was performed for MRI examination once it arrived at the center. A Phillips Ingenia™ 3.0 Tesla MRI machine with the protocol outlined below was used to evaluate cartilage surface and T2 map value (Table 1). The stifle joint was positioned in the pediatric human forearm coil (Fig. 1).

Because this is the first MRI done for the stifle sheep joint in our country, before the experiment, we preliminary optimized the MRI protocol to obtain a good visualization of the cartilage and the measurement of the T2 map.

To confirm the low-grade OA, we evaluated the stifle joint using OA macroscopic evaluation by Osteoarthritis Research Society International (OARSI). Joint cartilage and synovial tissue examination by gross observation using the semiquantitative OARSI method based on three parameters: cartilage damage, osteophytes, and synovial characteristics. The assessment was performed numerically for each component and conducted by two researchers. Each component of the OARSI macroscopic assessment and its elaboration can be seen in Supplementary Table 1.

We divided the stifle joint into three compartments, which were cranial (patella and trochlea), medial (femoral and tibial), and lateral (femoral and tibia). While the index compartment was the lateral compartment where total lateral meniscectomy was performed, the T2 values of the other compartments were also determined. We performed

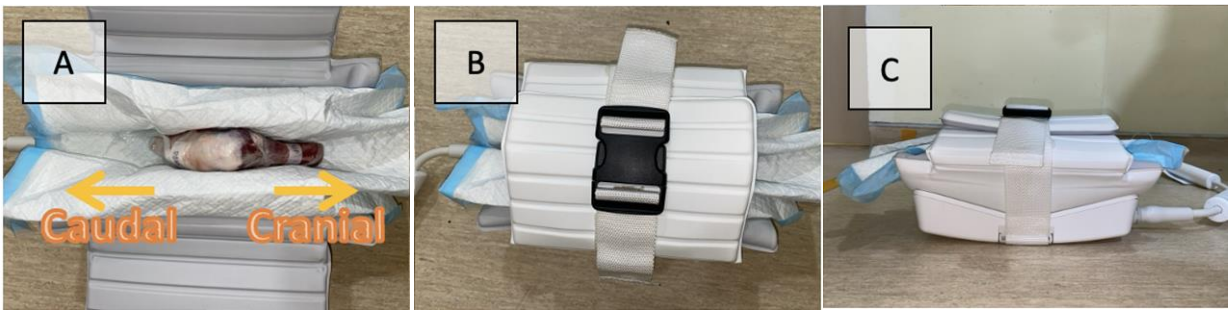

Fig. 1: Stifle joint position in the forearm coil.

Table 1: MRI 3.0 Tesla T2 Map protocol

Seq.	FOV (mm)	Matrix	NSA/NEX	TR	TE	Flip Angle	Scan Time
PD Sagital Non FatSat	100	356x355	1	2500	30	90	04.15
PD Ax-Femoro Non FatSat	60	184x184	1	2500	30	90	02.35
PD Coronal Non FatSat	100	288x288	1	2500	30	90	03.15
Cartigram Sagital	100	144x144	1	2600	N*12,5 (6 Echos)	90	04.23
Cartigram Ax-Femoro	60	120x120	1	1800	N*12 (6 Echos)	90	03.58
Cartigram Coronal	100	200x200	1	1800	N*12 (6 Echos)	90	05.38

Seq=Sequence; FOV=Field of View; NSA/NEX=Number of Signal Average/Number of Excitations; TR=Time Repetition; TE=Time Echo; PD=Proton-Density; FatSat=Fat Saturation; Ax-Femoro=Axial-Femoral

Supplementary Table 1: Macroscopic OARSI Evaluations Components

No	Parameters	Point
1.	Articular cartilage damage	
	Assessment of cartilage:	
	1. Normal.	0
	2. Rough surface.	1
	3. Fibrillation and fissures.	2
	4. Small erosions to subchondral bone (<5mm).	3
	5. Large erosions to subchondral bone (>5mm).	4
2.	Osteophyte Formation	
	Assessment of osteophytes:	
	1. Normal.	0
	2. Mild osteophyte formation (size <2mm or <20% of joint margin).	1
	3. Moderate osteophyte formation (size 2–4mm or 20-50% of joint margin).	2
	4. Large osteophyte formation (size >4mm or >50% of joint margin).	3
3.	Synovium Characteristics	
	Assessment of synovium:	
	1. Normal – opalescent white, semitranslucent, smooth with blood vessels sparsely distributed and clearly defined borders.	0
	2. Minimal – focal involvement, minimal discoloration, minimal thickening/fibrillation, minimal increased vascularity.	1
	3. Mild–diffuse involvement, minimal discoloration, consistent minimal thickening/fibrillation, moderate increased vascularity.	2
	4. Moderate – diffuse involvement, moderate discoloration, moderate fibrillation/thickening, moderate increased vascularity.	3
	5. Severe – diffuse involvement, severe discoloration, severe fibrillation/thickening, diffuse synovial proliferation with moderate hypervascularity.	4
	6. Profound – diffuse involvement, severe discoloration, very severe fibrillation/thickening, thickening to fibrosis with proliferation and diffuse hypervascularity.	5

descriptive statistical analysis to present the T2 and histological values and statistical analysis using ANOVA to find the significant difference between more than two groups with a significance level of $P<0.05$.

RESULTS

All eight sheep with a mean weight of 28±1.77kg were euthanized, and each proximal and distal stifle joints were transported within 1-3 hours and evaluated using T2 map evaluation by two board-certified radiologists specializing in musculoskeletal division from the central national referral hospital. After evaluating using T2 map evaluation, two of our researchers who were board-certified orthopedic knee surgeons also from the same institution, the first with a doctoral degree in the knee has been practicing knee for 30 years, and the latter a PhD candidate with a dissertation on this topic evaluate the macroscopic OARSI score for each stifle joint. Two specimens with a mean of 0.5±0.71 macroscopic OARSI score were included as the control group, while six others with a mean of 8.5±1.52 macroscopic OARSI score were included in the low-grade OA group (Fig. 2). Hence, we have established this study's control and low-grade OA groups.

Low-grade OA sheep stifle joint cartilage

All low-grade OA samples' mean total cartilage T2 relaxation time was 56.47±7.23ms throughout the compartment. Table 2 contains the breakdown of each compartment's T2 relaxation time of low-grade OA sheep. In the cranial compartment, the patella T2 relaxation time was 57.70±4.78ms, and the trochlea T2 relaxation time was 53.49±7.18ms with the sum of T2 relaxation time was 55.59±5.34ms (Fig. 3). No significant difference was

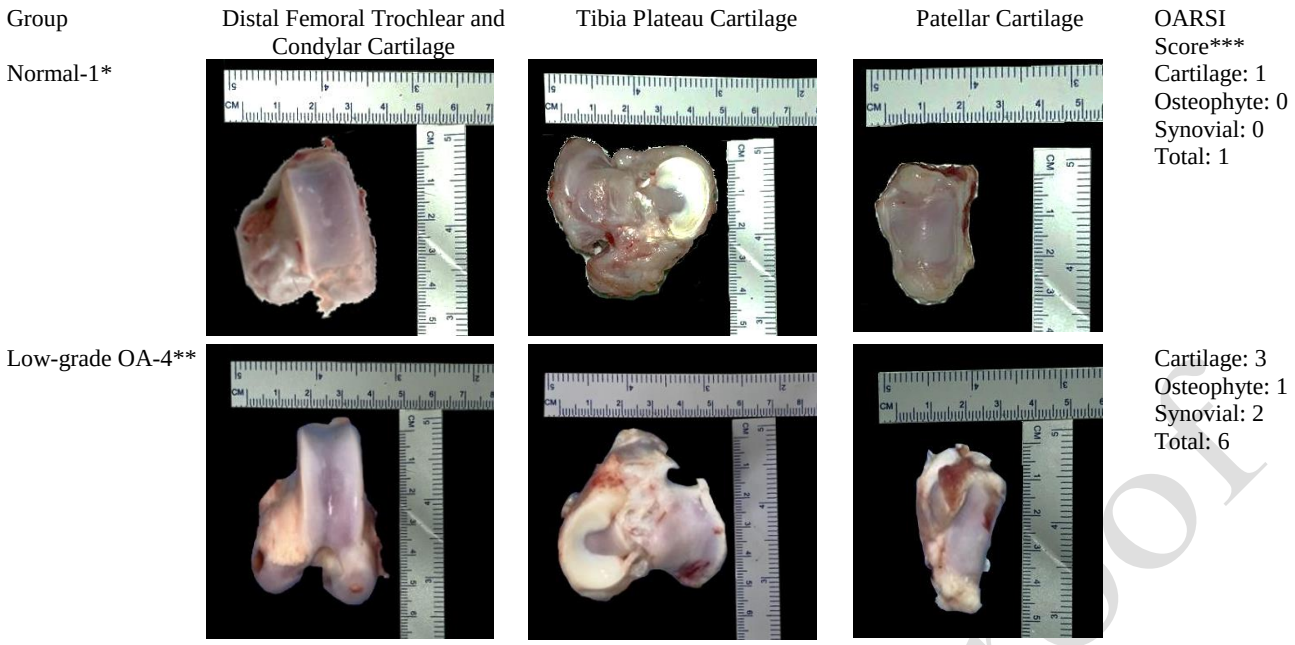

Fig. 2: Representatives of macroscopic OARSI evaluations results; *Normal-1, Sheep no. 1 cartilage appears within normal limit throughout the femoral, tibial and patellar bone with slight osteophyte formation less than 5mm; **Low-grade OA-4, Sheep no. 4 shows thinning cartilage in the trochlear area, patellar and lateral tibia plateau with osteophyte formation and synovial inflammation; ***OARSI score shown in the Supplementary Table 1.

Table 2: T2 relaxation time throughout compartment of low-grade OA sheep stifle joint cartilage

Compartments	Mean T2 relaxation time* (ms)			P -Value**
Cranial	Patella	Trochlea	Total	
	57.70±4.78	53.49±7.18	55.59±5.34	
Compartments	Femoral	Tibial	Total	
Medial	44.23±2.94	46.92±5.74	45.57±3.67	
Lateral	61.78±20.82	74.71±24.06	68.24±20.26	0.024

*T2 relaxation time in mean±SD (standard deviation) ms; ** Significant P<0.05

Table 3: T2 relaxation time in normal negative control sheep stifle joint cartilage

Compartment	Mean T2 relaxation time(ms)*			P -Value**
	Patella	Trochlea	Total	
Cranial	59.5±2.95	50.27±6.07	54.88±1.56	
Compartment	Mean T2 relaxation time (ms)*			P -Value**
	Femoral	Tibial	Total	
Medial	44.23±2.94	46.92±5.74	45.57±3.67	
Lateral	51.23±7.57	51.78±10.8	51.5±9.18	0.785

*T2 relaxation time of cartilage stifle joint in mean±SD (standard deviation) ms; **Significant P<0.05

observed in the cranial compartment. For the medial compartment, the femoral T2 relaxation time was 44.23±2.94ms, and the tibial T2 relaxation time was 46.92±5.74ms with a total T2 relaxation time of 45.57±3.67ms. There was no significant difference observed in the medial compartment. In the lateral compartment, we observed that the tibial has a T2 relaxation time compared to the other compartment (P=0.024) with femoral (74.71±24.06ms VS 61.78±20.82ms) and a total T2 relaxation time of 68.24±20.26ms.

Control sheep stifle joint cartilage

Control sheep right hind limb stifle joint T2 relaxation time was observed in Table 3. The control sheep had no significant difference between cranial, medial, and lateral results (P=0.785). The cranial compartment's patellar cartilage T2 relaxation time was 59.5±2.95ms, while the T2 relaxation time for the trochlear cartilage was 50.27±6.07ms. The total T2 relaxation time of the cranial compartment was 54.88±1.56 (Fig. 4). The T2 relaxation time for the femoral and tibial of the medial compartment consecutively were 44.23±2.94ms and 46.92±5.74ms. The total T2 relaxation time for the medial compartment was 45.57±3.67ms. For the lateral compartment, the T2 relaxation time of femoral and tibial cartilage were 51.23±7.57ms and 51.78±10.8ms with a total T2 relaxation time of 51.5±9.18ms. There was no significant difference in the T2 relaxation time of control sheep stifle joint cartilage in all compartments.

In most compartments, the low-grade OA group has a longer T2 relaxation time than the control group (Fig. 5; Fig. 6). However, both the control and the low-grade OA group produced similar results for the relaxation time of the medial compartment. The control group has a longer relaxation time for the cranial and lateral compartments than the low-grade OA group.

DISCUSSION

MRI has been the golden standard for the evaluation of articular cartilage. However, morphological changes in degenerative cartilage do not happen in early low-grade OA, which is challenging to assess in conventional MRI techniques (Zhao et al. 2022). T2 relaxation time is sensitive to the interactions between water molecules with the macromolecular concentration, as well as the structure of the extracellular matrix (Wang 2008; Pedoia et al. 2019). Fiber collagen orientation, water content, and tissue stiffness correlates with T2 relaxation time (Choi and Gold 2011; Mamisch et al. 2011). Hence, an increase in T2 map

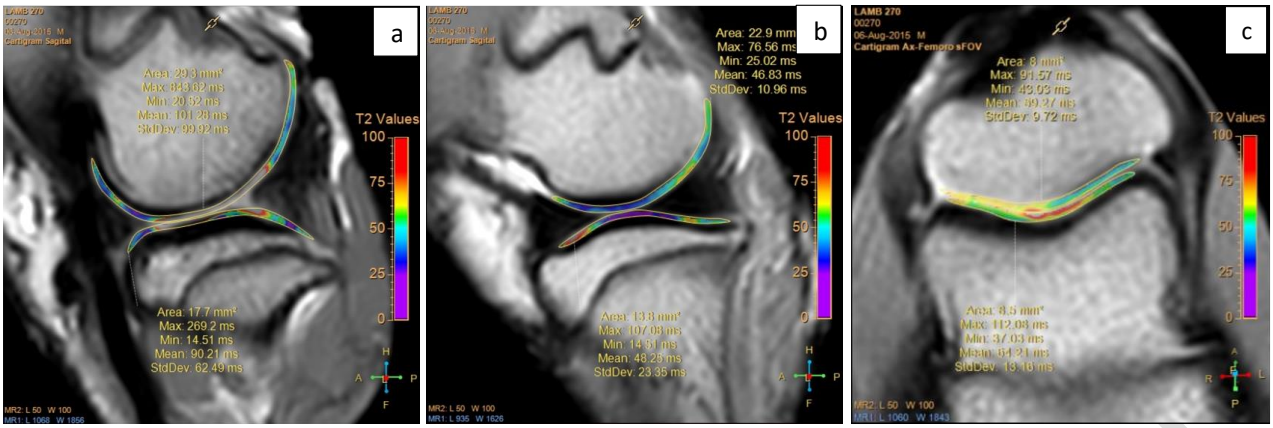

Fig. 3: T2 relaxation time of 12 weeks post lateral menictomised sheep. a, Lateral compartment with mean T2 relaxation time of 101.28ms in the femoral cartilage and 90.21ms in the tibial cartilage; b, Medial compartment with mean T2 relaxation time of 46.83ms in the femoral cartilage and 48.25ms in the tibial cartilage; and c, Cranial compartment with mean T2 relaxation time of 59.27ms in the patellar cartilage and 64.21ms in the trochlear cartilage region.

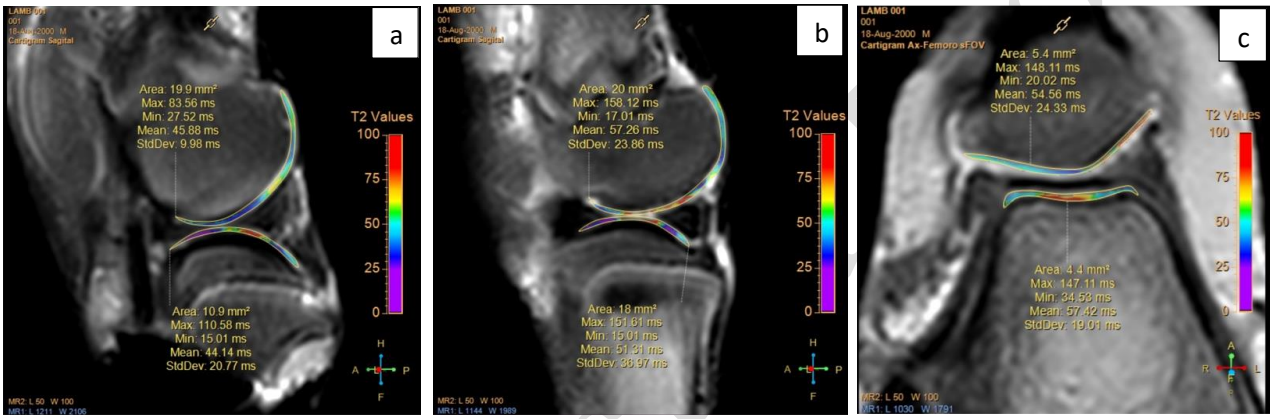

Fig. 4: T2 relaxation time of normal negative control sheep. a, Lateral compartment with mean T2 relaxation time of 45.88ms in the femoral and 44.14ms in the tibial; b, Medial compartment with mean T2 relaxation time of 57.26ms in the femoral and 51.31ms in the tibial; and c, Cranial compartment with mean T2 relaxation time of 54.64ms in the patella and 57.42ms in the trochlea region.

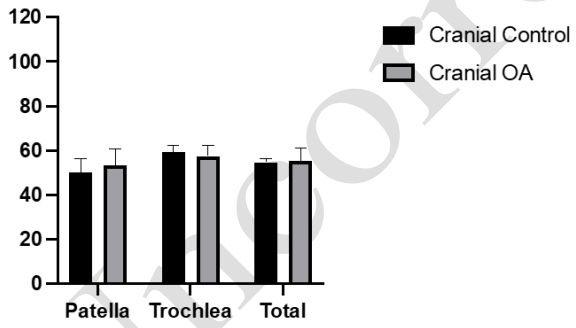

Fig. 5: Comparison between T2 relaxation time of the control group and the low-grade OA group cranial compartment.

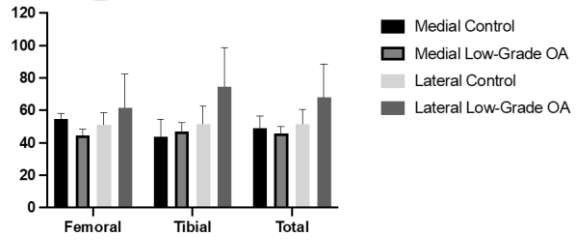

Fig. 6: Comparison between T2 relaxation time of the control group and the low-grade OA group medial and lateral compartments.

MRI imaging provides an impartial assessment of the damaged cartilage. Meanwhile, healthy individuals typically have low T2 relaxation times because water molecules are tightly bound within a well-organized fiber matrix (Zhao et al. 2022). This technique can improve sensitivity for detecting early alterations in tissue architecture and biochemical composition (Tsai et al. 2013; Pedoia et al. 2019). Several studies address that T2 map MRI reproducibility as its limitation. Nonetheless, previous studies have proved that the reproducibility of T2 mapping of cartilage was highly consistent (Albano et al. 2018; Chianca et al. 2019; Zhao et al. 2022). This study explored the T2 map MRI relaxation time evaluation in the sheep stifle model with low-grade OA. The results can enrich our knowledge of the proper methodology and expected results in using T2 map MRI in sheep stifle joint models with low-grade OA.

There are no established normal T2 mapping values for sheep stifle joints nor OA stifle joint values in the sheep. A previous study evaluated the T2 map value in cartilage after meniscal repair to evaluate temporal and zonal differences in meniscal structure and composition (Koff et al. 2013). This study, which aimed to evaluate cartilage changes after meniscal repair, was different from our study, which aimed to evaluate the cartilage condition in early OA (after meniscectomy).

Ovis aries "sheep" is one of the most common animal models used to study anatomy, physiology, and treatments of OA due to its similarity with human knee joints. However, establishing normal values is necessary to differentiate between the normal and pathological cartilage. In this study, we divided the stifle joint of the sheep into three compartments, cranial, medial, and lateral, with each surface in the femoral/tibial and trochlear/patellar cartilage. The methods for inducing OA in sheep models have been described in the previous study (Fiolin et al. 2024).

In this study, we have differentiated the control and low-grade OA groups objectively using the OARSI macroscopic score for OA. The mean macroscopic OARSI score for the control or normal group is 0.5±0.71ms, while the mean for the low-grade OA group is 8.5±1.52ms. For T2 relaxation time, we observed a mean T2 relaxation time value of 54.88±1.56ms in the cranial compartment, 45.57±3.67ms in the medial, and 51.5±9.18ms in the lateral compartment in the normal negative control sheep. Although T2 relaxation time will differ between imaging sequences and vendors, our study will provide an estimated value for further studies. We evaluated the mean T2 relaxation time in low-grade OA sheep differently in the indexed compartment vs. the other compartment significantly (P=0.024). In the lateral compartment, we found the mean T2 relaxation time of 68.24±20.26ms vs medial 45.57±3.67ms and cranial 55.59±5.34ms. This finding could infer that T2 relaxation time is a sensitive imaging that could differ low grade OA sensitively.

Overall, low-grade OA sheep have longer T2 relaxation than the control or normal group. Hence, these results aligned with previous studies that yielded the same result (Tsai et al. 2013; Wei et al. 2015; Franklin et al. 2019). A study by Tsai et al. 2013 in the rat model mentioned that they found a tendency toward an increase of T2 due to articular damaged cartilage, meniscus, and subchondral bone marrow during the progression of the disease (Tsai et al. 2013). Thus, the increase of T2 in OA is because of the loss of collagen and increased water content within the damaged cartilage and meniscus and subchondral bone marrow edema lesions. A study by Wei et al. 2015 found similar results in the rabbit model, where T2 relaxation time is sensitive and directly related to collagen content (Wei et al. 2015). Hence, T2 relaxation time increases in collagen structure breakdown and increase in the water content during OA progression (Apprich et al. 2012; Zhao et al. 2022). The increase in T2 relaxation time, triggered by changes in water content and collagen structure, is also supported by macroscopic changes obtained from macroscopic assessment in this study (Temple-Wong et al. 2009; Tschaikowsky et al. 2022).

A former study in the canine model by Franklin et al. (2019) stated several references for the normal T2 range in canines (Wei et al. 2015). Some references state the normal T2 ranges from 28–48ms in a normal canine knee, one study ranges from 52-70 in a normal canine elbow, and others state the normal range is 52-66ms in a normal canine knee (Wei et al. 2015). A study by Baker et al. 2022 in equine distal interphalangeal joint found lower T2 relaxation time in normal equine cartilage (40–61ms) than in pathological equine cartilage (83-104ms). However, higher T2 relaxation time does not correlate with increasing OARSI grade (Baker et al. 2022). Our study found that the normal range for T2 in ovine ranged from 45.57 to 54.88ms. Thus, it produces a similar result for the normal range of T2 mapping in the canine and equine. Our study obtained T2 relaxation time results higher than those reported in the prior study by (Koff et al. 2013). This difference may stem from variations in magnetic field strengths of the MRI machines, differences in tissue properties influenced by factors such as animal age, sex, and body weight, and specimen positioning (Wu et al. 2023).

Several studies have demonstrated T2 mapping MRI evaluation in other animals, such as horses, canines, rats, and rabbits (Tsai et al. 2013; Koff et al. 2013; Wei et al. 2015; Franklin et al. 2019; Nykänen et al. 2019). In a rabbit OA model, Wei et al. (2015) utilized high-field 7.0 T MRI T2 mapping to detect cartilage matrix changes caused by immobilization. Another study by Nykanen et al. used 9.4 T MRI to evaluate the articular cartilage of the equine post-traumatic OA model (Nykänen et al. 2019). However, 3.0 T MRI is the latest MRI technology available in our country, and no specific research-purpose MRI is available.

To our knowledge, this study is the first to evaluate T2 map MRI of the low-grade OA sheep model worldwide. T2 measurement values enable researchers to assess articular changes non-invasively (Bunzendahl et al. 2023). This study provided a protocol for performing a T2 mapping evaluation in the sheep model. Information regarding T2 relaxation time from this study can be utilized as the benchmark T2 mapping in the sheep model for future research. However, this study has some limitations, including a relatively small sample size and lack of very high field MRI specialized for research in our country. Another limitation of this study is the disparity in participants between the control group and the low-grade OA group. This discrepancy arose due to ethical considerations in the research.

For future studies, this study has provided information regarding the protocol and the benchmark of T2 mapping results in normal and low-grade OA sheep models. As stifle joints resemble knee joints in humans, future research can use data from this research to monitor changes in sheep stifle joints and to monitor drug evaluation that can be applied to humans. For veterinarians, this research may help gain further understanding regarding the pathogenesis and pathophysiology of OA and cartilage repair in stifle joints and sheep. In particular, T2 evaluation enables non-invasive evaluation of articular cartilage (Bunzendahl et al. 2023).

Conclusion

MRI T2-mapping evaluation can detect relaxation time changes in sheep's distal femoral, proximal tibia, and patellar cartilages with low-grade OA. The normal sheep T2 relaxation time ranges from 45.57–54.88ms, while the low-grade OA sheep T2 relaxation time ranges from 45.57–88.50ms throughout compartments, with the indexed compartment significantly showing the highest T2 relaxation time. This study has the potential to function as a dependable source to track changes in OA progression and to evaluate the effectiveness of potential therapeutic agents in sheep and as a model in humans.

Conflict of interest: None

Funding: Badan Riset dan Inovasi Nasional RIIM 2022.

Author's contribution

Each author made significant individual contributions to the development of this manuscript: LAPP and JF conceived ideas; BPP performed surgeries; KH performed MRI analysis; IHD, LAPP, and BPP reviewed the article and intellectual concept; LAPP and JF performed data analysis; and JF and JAH wrote and quality-controlled the article. All authors have reviewed the manuscript and agreed for publication.

Abbreviations

Ax-Femoro:	Axial-Femoral
FatSat:	Fat Saturation
FOV:	Field of View
KOA:	Knee Osteoarthritis
MRI:	Magnetic Resonance Imaging
MS:	Millisecond
NEX:	Number of Excitations
NSA:	Number of Signal Average
OA:	Osteoarthritis
PD:	Proton-Density
Seq.:	Sequence
TR:	Time Repetition
TE:	Time Echo

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