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Utility of axial magnetic resonance images for detecting meniscal ramp lesions associated with anterior cruciate ligament injuries

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ABSTRACT

Background: Ramp lesions (RLs), associated with anterior cruciate ligament (ACL) injuries, should be repaired to ensure postoperative knee stability. However, it is difficult to identify all RLs before surgery using conventional sagittal magnetic resonance (MR) images and arthroscopy from the anterior, medial, and lateral portals that are usually used during ACL reconstruction. We report the effectiveness of axial images for detecting RL.

Methods: From January 2018, a total of 316 knees underwent primary ACL reconstruction with preoperative magnetic resonance imaging (MRI) examination at our hospital. Among these, 149 knees, which required meniscal suturing at the same time, were retrospectively investigated. This study evaluated 22 knees with confirmed RLs around the posterior horn of the medial meniscus. The effectiveness of the preoperative sagittal and axial MR images for detecting RL was assessed. With the MR image, a three-dimensional double-echo steady-state image with a flip angle of 25° was reconstructed into the sagittal and axial planes, respectively. Reconstructed images with 3-mm slices for sagittal slices and 1-mm slices for axial sections were used. The diagnosis was made based on the presence of RL (RL was present, RL may be present, and RL was not present) by four knee surgeons with more than 10 years of experience.

Results: Approximately 53% of knee cases were diagnosed with RLs using sagittal images. Meanwhile, a diagnosis was achieved using axial images in 89% of cases.

Conclusion: Axial MRI may be superior in detecting RLs.

1. Introduction

Ramp lesions (RLs), associated with anterior cruciate ligament (ACL) injuries, are integral to knee stability by increasing the tension forces in the ACL.[1] RLs should be repaired to ensure postoperative knee stability.[2] However, it is difficult to detect RLs before surgery using conventional sagittal magnetic resonance imaging (MRI) and arthroscopy from the anteromedial and lateral portals, used during ACL reconstruction.[3] The sagittal images of a longitudinal tear around the medial posterior horn are tangent due to the curvature of the meniscus, and the diagnostic rate is reportedly low. However, with axial imaging, the tear is sliced vertically. This reportedly increases the diagnostic rate. This study aimed to clarify the utility of axial MR images for RL detection (see Tables 1 and 2).

2. Materials and methods

For three years since January 2018, a total of 316 knees underwent primary ACL reconstruction with a preoperative MRI examination at our hospital. Among these, 149 knees, which required concomitant meniscal suturing, were retrospectively investigated. The study included 22 knees with confirmed RLs with a gap between the posterior capsule and the base of the posterior horn on arthroscopic imaging records. The effectiveness of preoperative sagittal and axial MR images for detecting RLs was assessed. The average age was 23.0 years (13–51) (male/female: 11/11, right/left: 7/15 knees). For MR images (3 Tesla Magnetom Verio, Siemens Healthcare Sector, Erlangen), three-dimensional double-echo steady-state (3D-DESS) images were reconstructed into sagittal and axial planes, respectively, using the flip angle of 25°. Reconstructed images with 3-mm slices for sagittal and 1-mm slices for axial planes were used.

Eighteen cases without RLs were added to the cohort. Four

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Table 1
Determination with sagittal images.

Physician	A	B	C	D	Average
(a) RL was present	6	2	8	5	
(b) RL may be present	5	9	3	9	
(c) RL was not present	11	11	11	8	
(a)+(b)	11	11	11	14	11.75(53.4%) n = 22

Table 2
Determination with axial images.

Physician	A	B	C	D	Average
(a) RL was present	22	10	15	10	
(b) RL may be present	0	8	3	10	
(c) RL was not present	0	4	4	2	
(a)+(b)	22	18	18	20	19.5(88.6%) n = 22

blinded physicians with more than 10 years of experience with knee arthroscopic surgery were asked to evaluate the images of the 40 cases. Since this was a cohort study, the examiner was not aware of the number of correct answers; therefore, we created study conditions to enable the simple determination of the presence or absence of an RL lesion.

First, a series of sagittal images, reconstructed by 3D-DESS, were extracted from the MR images of each case. The images, burned on independent CD-ROMs, were prepared and submitted for evaluation. The axial images were similarly prepared and submitted for evaluation. None of the four physicians previously diagnosed RLs using axial slices. The presence of joint fluid infiltration along the posterior margin of the medial posterior horn was found in the RL-positive cases (Fig. 1). The diagnosis was made based on the presence of RL (RL was present, RL may be present, and RL was not present.) The physicians determined that 'RL was present' when RL could be definitively diagnosed, and that 'RL may be present' when abnormal high intensity lesion was confirmed without enabling confirmation of RL. Cases were diagnosed as having no RL ('RL was not present') when observed tears were clearly in a different direction, such as horizontal.

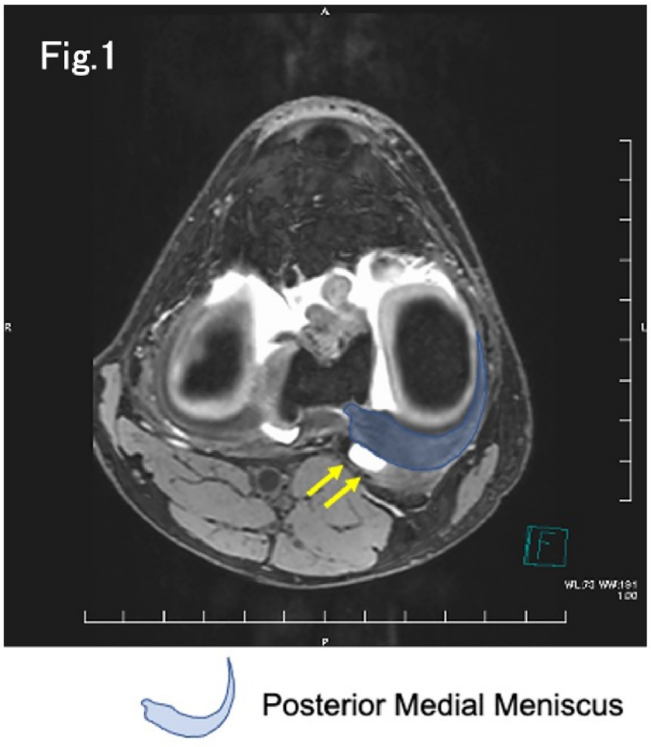

Fig. 1. A magnetic resonance image of a ramp lesion (RL) in the axial plane. An RL (arrow) defined as fluid signal intensity just behind the posterior horn of medial meniscus.

Informed consent was obtained through the opt-out form of the study website (https://www.ichihara-hospital.or.jp/kenyukai/agreement.html). Rejected subjects were excluded from the study.

All procedures used in this study were approved by the Ethical Committee of Ichihara Hospital (approval number: 2102).

Nonnumerical variables were compared using the chi-square test. Results with a P-value less than 0.05 were considered statistically significant.

3. Results

RL was confirmed in 53% of the cases, including probable cases. Meanwhile, 88.6% (significantly greater than sagittal images; P = 0.01) of RLs were identified by axial images.

Case 1. ; 19-year-old male

In this case, all four physicians determined that there was or may have been an RL based on the sagittal and axial plane images (Fig. 2).

Case 2. ; 14-year-old female

In this case, three of four physicians judged that there was no RL, while one physician suspected a possible RL based on the sagittal images. However, all four identified an RL based on the axial images (Figs. 3 and 4).

4. Discussion

In this study, 53% of RL cases were detected on sagittal MRI. The detection rate improved to 88.6% with axial MRI. Since axial imaging slices the tear of the RL vertically, it is advantageous for detecting RLs. The 3D-DESS reconstructed images are useful for investigating the MRI sequence parameters to assess articular cartilage, which wraps around complex anatomical structures as a thin sheet. Moreover, this process effectively detects thin meniscal tears.[4]

The sensitivity of sagittal MR images for RLs ranged from 48% to 86%.[5] According to Hatayama et al. on sagittal imaging, abnormalities were observed in the joint capsule attachment, near the medial posterior horn, in 12 of 21 knees. The remaining nine knees had no abnormal MRI findings.[6] In the current study, the detection rate of sagittal MR images was lower than that of previous reports.

When the posterior horn is attached at an angle to the frontal plane, as in Case 2, the 3-mm slices become too thick to detect lesions at the margin. This contributes to the difficulty in using sagittal imaging to identify lesions.

It is easy to detect clinically problematic RLs larger than 1 cm from MRI sagittal slices. Nevertheless, the low diagnostic rate on MRI may be due to the fact that even if a tear is present, the ruptured portion may be closed with the ends in contact at the time of MR imaging, so it is a lesion of sufficient length on MRI. It may be because it is not identified. Ruptures occur in various directions, including vertical orientation tears. When the posterior horn is attached at an angle to the frontal plane, as in Case 2, the 3-mm slices become too thick to detect lesions at the margin. This contributes to the difficulty in using sagittal imaging to identify the lesions. To address this, the angle of the sagittal slices should be adjusted, or the images should be reconstructed using thinner slices such as 1-mm slices, which is the same thickness used for axial

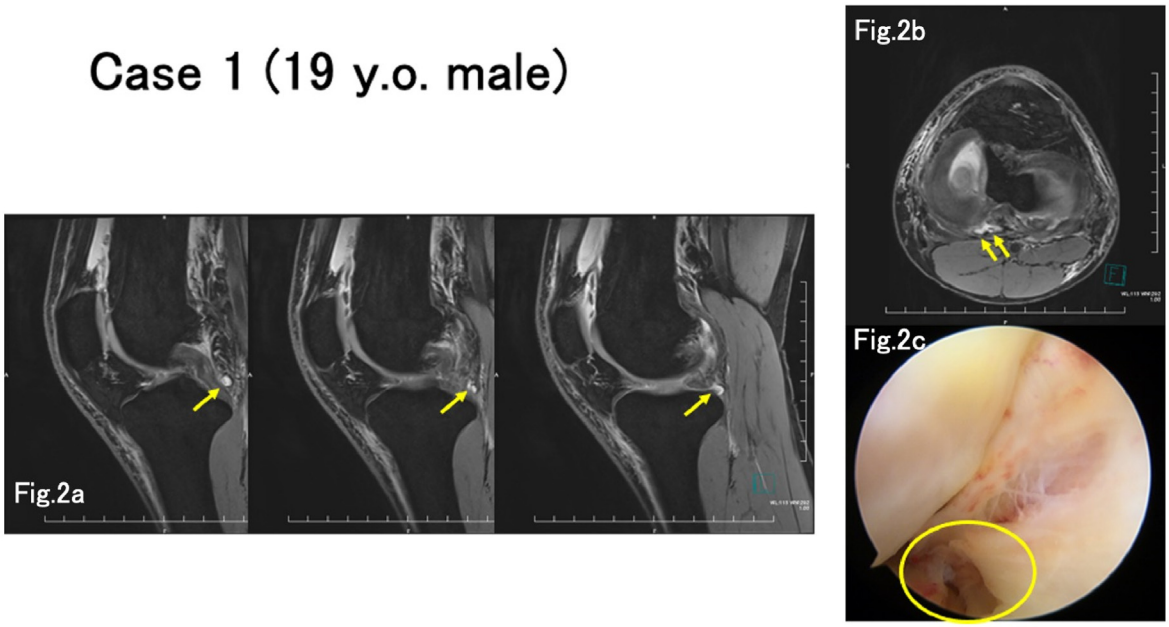

Fig. 2. Case 1; 19-year-old male. (a) Magnetic resonance imaging of a ramp lesion (RL) (arrow) in the sagittal plane. (b) An RL (arrow) in the axial plane. The RL can be easily identified by either slice. (c) Intraoperative right knee meniscal ramp lesion (circle) around the medial posterior horn of this case.

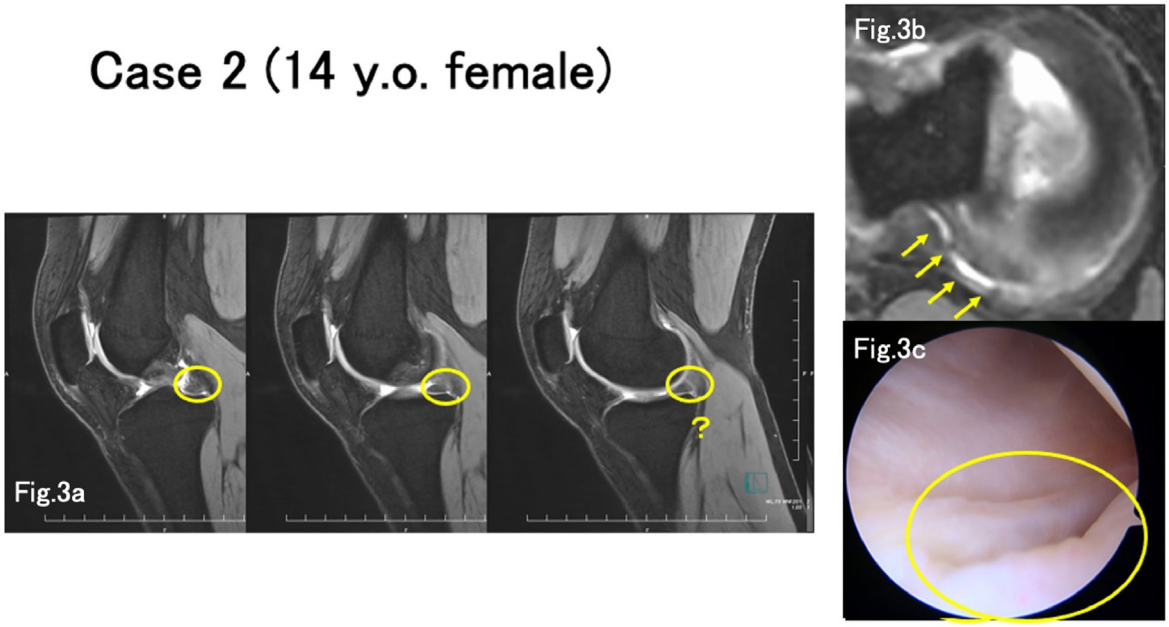

Fig. 3. Case 2; 14-year-old female. (a) A magnetic resonance image of a ramp lesion (RL) (arrow) in the sagittal plane. The RL cannot be clearly identified by these planes. (b) An RL (arrow) in the axial plane. The RL can be easily detected in the axial plane. (c) Intraoperative left knee meniscal ramp lesion (circle) around the medial posterior horn of this case.

MR images in this study. However, the clinical problem persists in that the transverse fissure of the base that the joint capsule and meniscus itself understand. We suggest that axial images were advantageous for detecting RLs in our study due to the direction of the ruptures.

When MR imaging is completed in the flexed position, stress is applied to separate the posterior capsule and the meniscus, which may make it easier to identify lamp lesions. However, unlike posterior cruciate ligament injury, RL cannot be detected by physical examination. Furthermore, completion of an MRI with an injured knee in the flexed position is challenging due to potential patient discomfort, especially immediately after anterior cruciate ligament injury.

To the best of our knowledge, this is the first study to investigate the detectability of RLs on axial imaging, based on the judgement of four physicians. Diagnostic accuracy was higher based on axial imaging than on sagittal imaging. Its predictive value is expected to increase with its clinical application. RLs are classified into five types according to Thaunat's classification.[7] Axial imaging effectively identified type III RLs, which are challenging to identify using

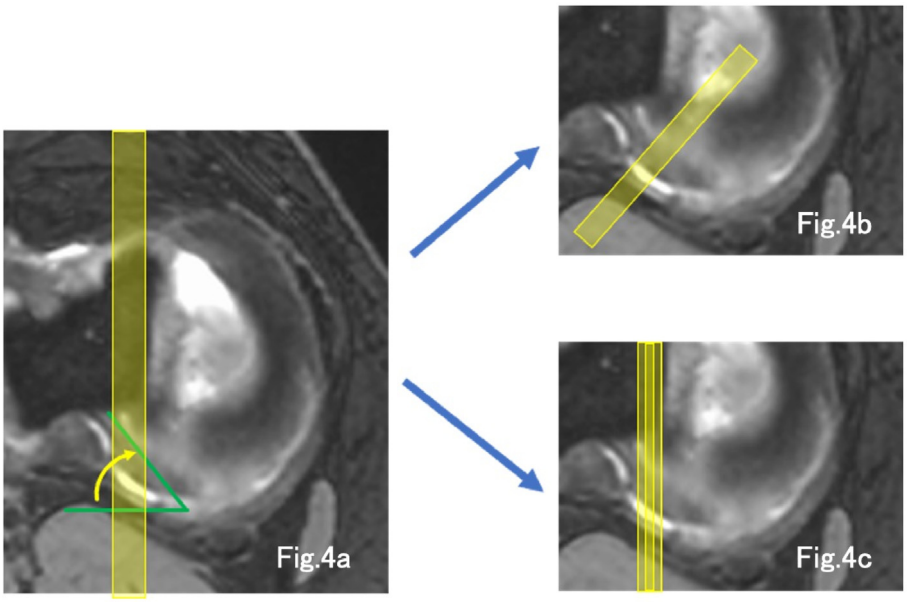

Fig. 4. Case 2; 14-year-old female. (a)The posterior horn is attached at an angle (green) to the frontal plane. Since the signal strength of this 3-mm width (yellow band) is averaged, it becomes difficult to detect the lesion. (b) Adjustment of the angle of the sagittal slices, or (c) reconstruction using thinner slices helps identify a ramp lesion. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

an arthroscope. Our results suggest that comprehensive diagnosis using multi-directional images as well as one-directional images will improve accuracy of diagnosis.

5Limitations

Some limitations of this study must be addressed. First, this study had a small sample size. Second, in addition to the positive RL cases included in this study, some RL cases may have been overlooked.

6. Conclusions

Axial MR images are useful for detecting meniscal RLs.

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Declaration of competing interest

The author(s) have no conflicts of interest relevant to this article.

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