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A posterior shiny-corner lesion of the tibia is observed in the early phase after medial meniscus posterior root tear

--Manuscript Draft--

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Abstract:	Background Medial meniscus (MM) posterior root tear (PRT) results in joint overloading and degenerative changes in the knee, and pullout repair is recommended to prevent subsequent osteoarthritis. Diagnosing MMPRT is sometimes difficult, especially in the case of an incomplete tear. A posterior shiny-corner lesion (PSCL) is reported to be useful for diagnosis, although the association between MMPRT and PSCL is unknown. This study aimed to investigate the properties of PSCL, such as the location, volume, and duration from injury to the time of MRI (duration). We hypothesized that PSCL is observed in the early phase after the MMPRT onset. Methods T2-weighted fat-suppression MRI was obtained from 55 patients with MMPRT preoperatively. The prevalence of the PSCL; giraffe neck, cleft, and ghost signs; severe MM extrusion (>3 mm); and the PSCL volume were evaluated. The PSCL lesion elliptical volume (mm 3) was calculated by measuring the anteroposterior, transverse, and craniocaudal dimensions. Results

	PSCL was observed in 34 (62%) cases. The mean volume of the PSCL was 102.0 mm ^{3} . A significantly shorter duration was observed in the PSCL positive group (5.6 weeks) than that in the PSCL-negative group (40.9 weeks, $P<0.01$), although no significant correlation was observed between the PSCL volume and duration. The sensitivity for the MMPRT was 90.5% when the cutoff duration value was 3 weeks and 81.8% when the cutoff value was 8 weeks. Conclusions MRI examination may detect PSCL if it is performed early following MMPRT onset. Detecting PSCL may be useful in diagnosing MMPRT with high sensitivity.

We would like to thank you for your response and for giving us the opportunity to improve and resubmit our manuscript (ID: EJOS-D-21-00095) entitled "A posterior shiny-corner lesion of the tibia is observed in the early phase after medial meniscus posterior root tear." We are hereby resubmitting a revised manuscript conforming to all of the reviewer's comments with revisions indicated in underlined red font. Additionally, we have addressed all the reviewers' comments in a point-by-point manner and attached it herewith.

We would like to thank you and the reviewers for your thoughtful suggestions and insights, which have enriched the manuscript and produced a more balanced and better account of the research. We hope that the revised manuscript is now suitable for publication in your journal.

Thank you for your consideration. We look forward to hearing from you.

Sincerely,

COMMENTS TO THE AUTHOR:

Reviewer's Responses to Questions

Content of manuscript

Purpose	Reviewer #1:*Clear
Originality	Reviewer #1:*Acceptable
Importance of the subject	Reviewer #1:*Outstanding
Integration of the most recent data	Reviewer #1:*Complete
Scientific writing/structure	Reviewer #1:*Outstanding

Response: Thank you for the positive comments.

Content of manuscript:	
Reviewer's comments/suggestions	Reviewer #1: The content of manuscripts is good.
Materials	Reviewer #1:*Appropriate

Response: Thank you for the positive comments.

Materials:	
Reviewer's comments/suggestions	Reviewer #1: The given material is good.
Methods	Reviewer #1:*Need clarification

Methods : Reviewer's comments/suggestions

Reviewer #1:

1. The mean duration from injury to MRI was 13.1 ± 18.6 days.

2. A significantly short duration was observed in the PSCL-positive group (5.6 ± 7.9 weeks) compared with that in the PSCL-negative group (40.9 ± 25.4 weeks)

Kindly clarify the content in the above mentioned lines with regard to the days and weeks.

Response: Thank you for the comment and we are sorry for our mistake. We have revised manuscript to indicate duration from injury to surgery in weeks (Pages 2 and 4).

References

The number of references Reviewer #1: *Outstanding literature review/citations

References:

Reviewer's comments/suggestions Reviewer #1: Good review of literature

Response: Thank you for the positive comments.

Iconography and charts

Iconography Reviewer #1:*Satisfactory/need explanation

Charts Reviewer #1:*Adequate

Response: Thank you for the comments. We have revised manuscript according to your comments.

Iconography and charts:

Reviewer's comments/suggestions

Reviewer #1: Please clarify Duration from injury to MRI

Reviewer #1: Please clarify if the mean duration from injury to MRI is in days or weeks.

Response: Thank you for the comments. We checked the duration from injury to MRI carefully. We also checked figure legend, which was correct. We have revised manuscript to indicate duration in weeks (Pages 2 and 4).

A posterior shiny-corner lesion of the tibia is observed in the early phase after medial meniscus posterior root tear

1. Introduction

Medial meniscus (MM) posterior root tear (PRT) is of interest to several researchers, and a number of clinical, biomechanical, and histological studies on MMPRT have been conducted [1-5]. MM posterior root lesions are commonly detected in symptomatic patients [6], and determining the characteristic findings in these patients provides a high diagnostic accuracy [7]. A biomechanical approach in magnetic resonance imaging (MRI) interpretation helps assess osseous contusion and ligament rupture and detects delicate (but significant) abnormalities [4]. Because MMPRT results in joint overloading and degenerative changes in the knee [8], and may lead to arthroplasty [1,2,9], an accurate diagnosis of MMPRT from a popping episode and MRI is important [10,11], and pullout repair is recommended to prevent sequential osteoarthritis [1,12,13]. Specific medical history (painful popping episode) [10,11]; bone geometry [14,15]; and characteristic findings such as giraffe neck, cleft/truncation, and ghost signs and severe MM extrusion (MME) (> 3 mm) have been reported [13]. These have enabled us to diagnose MMPRT in the early phase. Furthermore, severe posteromedial extrusion in the knee-flexed position has been reported [16,17], although open MRI in the knee-flexed position cannot be performed in all institutions.

Although several studies have reported the diagnosis of MMPRT as mentioned earlier, a diagnosis of MMPRT is sometimes difficult, especially in cases of an incomplete tear. In such cases, a posterior shiny-corner lesion (PSCL),

which is a bone marrow lesion at the meniscal-covered portions of the posterior tibial plateau, has been reported to be a useful finding following an MM tear (including MMPRT) and may be helpful for diagnosis [18]. It is reported that a tear of the MM or root ligaments could be detected by a shiny-corner lesion with relatively low sensitivity (62%) and extremely high specificity (97%) [18]. However, the association between MMPRT and PSCL is still unknown. Thus, this study aimed to investigate the properties of PSCL, such as the location, volume, and duration from injury to the time of MRI (duration). We hypothesized that PSCL is likely observed in the early phase after MMPRT.

2. Materials and Methods

2.1. Patients and ethical considerations

Fifty-five patients who underwent surgery for MMPRT between March 2015 and March 2019 at our hospital were retrospectively evaluated. Of the total 221 patients, 166 were excluded because they had an unclear joint popping episode, a history of surgery on the same side, and unavailable MRI data. Among the 55 included patients, 3 (5.5%) underwent total knee arthroplasty, 4 (7.3%) underwent unicompartmental knee arthroplasty, and 48 (87.3%) underwent transtibial pullout repair. Medical records were reviewed to examine age, height, body weight, and duration (weeks), and MR images were examined. All patients were diagnosed with MMPRT based on MRI findings, such as cleft, giraffe neck, and ghost signs; radial tear; and meniscal extrusion (> 3 mm) [7,13]. The MMPRT classification was defined following a previous study using arthroscopy (in the case of pullout repair) or directly (in the case of arthroplasty) [19]. This study and all protocols were approved by the institutional review

board, and informed consent was obtained from all individual participants included in the study.

2.2. Methods

Imaging evaluation was performed using an Achieva 1.5T scanner (Philips, Amsterdam, The Netherlands) or Excelart Vantage^{TM} powered by Atlas 1.5T with an integrated coil (Toshiba Medical Systems, Tochigi, Japan). The standard sequences included sagittal/coronal (TR/TE 5,000/107) T2-weighted fat suppression with a 90° flip angle. The slice thickness was 4 mm with a 0.6-mm gap. The field of view was 16 × 16 cm, with an acquisition matrix size of 512 × 410. The slice thickness was 3 mm, with a 0.6-mm gap. The field of view was 18 cm, with an acquisition matrix size of 224 × 320.

The presence, location, and volume of the PSCL were evaluated. The PSCL was defined as a focal, peripheral hyperintense lesion at the aspect of the posterior medial tibial plateau, corresponding to the meniscal-covered regions as previously described [18]. Cyst-like lesions and marrow alteration immediately deep to the root ligament entheses were not included in the definition of a shiny corner per the original paper [18] because subcortical cysts are associated with ligament or meniscal pathologies [20]. The expected anatomic center of the MM posterior root attachment was defined at 10 mm posterior from the medial tibial eminence apex [21]. The volume of the PSCL (mm^3) was calculated by measuring the anteroposterior (AP, in the sagittal plane), transverse (TR, in the coronal plane), and craniocaudal (CC, in the coronal plane) dimensions using the following formula: volume = 4/3 × (πabc), where a, b, and c are the AP, TR, and CC dimensions (mm), respectively [22].

2.3. Methods of assessment

MR images were evaluated by two experienced orthopedic surgeons (with 6 and 7 years of experience in performing radiologic interpretation, including MRI and surgically treating patients); they independently assessed the prevalence of the PSCL; giraffe neck, cleft, and ghost signs; and presence of MME (> 3 mm). Each observer performed each evaluation twice, at least 2 weeks apart. In the event the assessments were inconsistent, the most experienced surgeon in the operation team assessed the findings with a spot consultation.

2.4. Statistical analyses

Data are reported as mean ± standard deviation. All statistical analyses were performed using the EZR software (Saitama Medical Center, Jichi Medical University, Tochigi, Japan). Differences in the subject's demographics between the two groups were evaluated using the Mann–Whitney U test. P values < 0.05 were considered statistically significant. The reliability of the image analysis was assessed by the simple kappa coefficient. Kappa values were categorized as follows: > 0.8, very good; between 0.6 and 0.8, good; between 0.4 and 0.6, moderate; between 0.2 and 0.4, fair; and < 0.2, poor. These values were calculated to determine the intra- and inter-observer reproducibility.

3. Results

The patient demographics are shown in Table 1. The mean duration from injury to MRI was 13.1 ± 18.6 weeks. PSCL was observed in 34 (61.8%) cases, and it was on the posteromedial side of the MM posterior root attachment

in all cases (Fig. 1). The mean volume of PSCL was 102.0 mm^3. A significantly short duration was observed in the PSCL-positive group (5.6 ± 7.9 weeks) compared with that in the PSCL-negative group (40.9 ± 25.4 weeks, $P < 0.01$, power = 1; Fig. 2), whereas no significant correlation was observed between the PSCL volume and duration. The results of the sensitivity for the MMPRT of each finding (within each duration) are shown in Tables 2. The sensitivity of PSCL was 90.5% (19/21) when MRI was performed within 3 weeks after injury and 81.8% (27/33) when it was within 8 weeks. When evaluating only MRI within 3 weeks after injury, the sensitivity of the PSCL was higher than any other findings. When evaluating MRI within 8 weeks after injury, the sensitivities of the giraffe neck, ghost signs, and PSCL were similar and higher than that of cleft sign or severe MME (> 3 mm). In one case, where MRI was performed twice preoperatively (at 3 and 56 days), an outstanding PSCL shown on the first MRI had become pale in the second MRI (Fig. 3).

The concordance between the two observers (inter-observer reliability) was very good for PSCL ($k = 0.81$). Furthermore, the intra-observer reliability was very good ($k = 0.92$).

4. Discussion

The most important finding of this study is that PSCL is likely to be observed on the posteromedial side of the anatomic attachment in the early phase after MMPRT.

In the present study, the sensitivity was higher than those of previous studies [18] when MRI examinations within 8 weeks were evaluated, although the volume was not associated with the duration. We considered that the PSCL occurred at the time of injury due to minor trauma and gradually improved and the subchondral lesions became

free from loading after the tear. These results are consistent with previous findings indicating that bone bruising is less severe and regresses within a short period after low-energy trauma, whereas the healing of lesions caused by high-energy trauma, such as those due to anterior cruciate ligament injury, may take years [23]. We considered that a low sensitivity for the MMPRT of the cleft sign and severe MME was caused by the short duration because the duration is too short in this study, although MME would progress and a cleft sign would become positive after MMPRT [24,25]. The result of the present study suggests that MRI examination in the early phase after MMPRT is recommended to detect PSCL with a high sensitivity for the diagnosis of MMPRT.

Furthermore, the PSCL was located on the posteromedial side of the MM posterior root attachment, and MMPRT classification 2b (3–6 mm from the tibial attachment, 30 cases) was much more frequent than type 2a (0–3 mm, 8 cases) or 2c (6–9 mm, 7 cases). From these results, we consider that the posteromedial part of the anatomic attachment is exposed to strong stress, although the structure of the MM posterior root insertion was mainly localized in the anterior one-third [3].

This study has some limitations. First, the sample size was small, which might result in no correlation between duration and the PSCL volume. Second, only patients who had painful popping episode were include because we want to analyze the association between duration from injury to surgery and PSCL. When we focus on reporting sensitivity/specificity, all patients who had posterior knee pain should be included. Third, MR images were not examined twice in all cases. Images were evaluated at only one time point, and the course of the PSCL change was not evaluated. Individual differences in the frequency of PSCL or bone mineral density were also not evaluated. Thus, preoperative MRI examinations at two different time points per patient may be useful to obtain

more sensitive results. Finally, the surgeons who contributed to MRI evaluation were not blinded from the status of MM posterior root because all included patients were surgically treated.

In conclusion, a PSCL may be useful in diagnosing MMPRT when an MRI examination is performed in the early phase following the MMPRT onset. Early MRI examination after MMPRT may be recommended to detect a PSCL with high sensitivity for the diagnosis of MMPRT.

References

1. Bernard CD, Kennedy NI, Tagliero AJ, Camp CL, Saris DBF, Levy BA, Stuart MJ, Krych AJ (2020) Medial Meniscus Posterior Root Tear Treatment: A Matched Cohort Comparison of Nonoperative Management, Partial Meniscectomy, and Repair. The American journal of sports medicine 48 (1):128-132. doi:10.1177/0363546519888212

2. Chung KS, Noh JM, Ha JK, Ra HJ, Park SB, Kim HK, Kim JG (2018) Survivorship Analysis and Clinical Outcomes of Transtibial Pullout Repair for Medial Meniscus Posterior Root Tears: A 5- to 10-Year Follow-up Study. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association 34 (2):530-535. doi:10.1016/j.arthro.2017.08.266

3. Hino T, Furumatsu T, Miyazawa S, Fujii M, Kodama Y, Kamatsuki Y, Okazaki Y, Masuda S, Okazaki Y, Ozaki T (2020) A histological study of the medial meniscus posterior root tibial insertion. Connect Tissue Res 61 (6):546-553. doi:10.1080/03008207.2019.1631298

4. Sahoo K, Garg A, Saha P, Dodia JV, Raj VR, Bhairagond SJ (2016) Study of Imaging Pattern in Bone Marrow Oedema in MRI in Recent Knee Injuries and its Correlation with Type of Knee Injury. Journal of clinical and diagnostic research : JCDR 10 (4):Tc06-11. doi:10.7860/jcdr/2016/18843.7704

5. Sharif B, Ashraf T, Saifuddin A (2020) Magnetic resonance imaging of the meniscal roots. Skeletal Radiol 49 (5):661-676. doi:10.1007/s00256-020-03374-3

6. Choi JY, Chang EY, Cunha GM, Tafur M, Statum S, Chung CB (2014) Posterior medial meniscus root ligament

lesions: MRI classification and associated findings. AJR Am J Roentgenol 203 (6):1286-1292. doi:10.2214/AJR.14.12559

7. Choi SH, Bae S, Ji SK, Chang MJ (2012) The MRI findings of meniscal root tear of the medial meniscus: emphasis on coronal, sagittal and axial images. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA 20 (10):2098-2103. doi:10.1007/s00167-011-1794-4

8. Marzo JM, Gurske-DePerio J (2009) Effects of medial meniscus posterior horn avulsion and repair on tibiofemoral contact area and peak contact pressure with clinical implications. The American journal of sports medicine 37 (1):124-129. doi:10.1177/0363546508323254

9. Sayyid S, Younan Y, Sharma G, Singer A, Morrison W, Zoga A, Gonzalez FM (2019) Subchondral insufficiency fracture of the knee: grading, risk factors, and outcome. Skeletal Radiol. doi:10.1007/s00256-019-03245-6

10. Bae JH, Paik NH, Park GW, Yoon JR, Chae DJ, Kwon JH, Kim JI, Nha KW (2013) Predictive value of painful popping for a posterior root tear of the medial meniscus in middle-aged to older Asian patients. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association 29 (3):545-549. doi:10.1016/j.arthro.2012.10.026

11. Lee DW, Moon SG, Kim NR, Chang MS, Kim JG (2018) Medial knee osteoarthritis precedes medial meniscal posterior root tear with an event of painful popping. Orthopaedics & traumatology, surgery & research : OTSR 104 (7):1009-1015. doi:10.1016/j.otsr.2018.07.010

12. Chung KS, Ha JK, Ra HJ, Kim JG (2016) A meta-analysis of clinical and radiographic outcomes of posterior horn medial meniscus root repairs. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA

24 (5):1455-1468. doi:10.1007/s00167-015-3832-0

13. Furumatsu T, Fujii M, Kodama Y, Ozaki T (2017) A giraffe neck sign of the medial meniscus: A characteristic finding of the medial meniscus posterior root tear on magnetic resonance imaging. Journal of orthopaedic science : official journal of the Japanese Orthopaedic Association 22 (4):731-736. doi:10.1016/j.jos.2017.03.013

14. Hiranaka T, Furumatsu T, Okazaki Y, Yamawaki T, Okazaki Y, Kodama Y, Kamatsuki Y, Ozaki T (2020) Steep medial tibial slope and prolonged delay to surgery are associated with bilateral medial meniscus posterior root tear. Knee Surgery, Sports Traumatology, Arthroscopy. doi:10.1007/s00167-020-06079-1

15. Okazaki Y, Furumatsu T, Kodama Y, Kamatsuki Y, Okazaki Y, Hiranaka T, Takihira S, Tetsunaga T, Saiga K, Ozaki T (2019) Steep posterior slope and shallow concave shape of the medial tibial plateau are risk factors for medial meniscus posterior root tears. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. doi:10.1007/s00167-019-05590-4

16. Okazaki Y, Furumatsu T, Okazaki Y, Masuda S, Hiranaka T, Kodama Y, Kamatsuki Y, Miyazawa S, Tetsunaga T, Ozaki T (2020) Medial meniscus posterior root repair decreases posteromedial extrusion of the medial meniscus during knee flexion. The Knee 27 (1):132-139. doi:10.1016/j.knee.2019.09.005

17. Okazaki Y, Furumatsu T, Yamaguchi T, Kodama Y, Kamatsuki Y, Masuda S, Okazaki Y, Hiranaka T, Zhang X, Ozaki T (2020) Medial meniscus posterior root tear causes swelling of the medial meniscus and expansion of the extruded meniscus: a comparative analysis between 2D and 3D MRI. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA 28 (11):3405-3415. doi:10.1007/s00167-019-05580-6

18. Chang EY, Chen KC, Chung CB (2014) The shiny corner of the knee: a sign of meniscal osteochondral unit

dysfunction. Skeletal Radiol 43 (10):1403-1409. doi:10.1007/s00256-014-1958-7

19. LaPrade CM, James EW, Cram TR, Feagin JA, Engebretsen L, LaPrade RF (2015) Meniscal root tears: a classification system based on tear morphology. The American journal of sports medicine 43 (2):363-369. doi:10.1177/0363546514559684

20. Son JY, Yoon YC, Jin W, Cha JG (2018) The prevalence and characteristics of a subcortical cystic lesion at the subspinous region of the knee. Acta radiologica (Stockholm, Sweden : 1987) 59 (1):97-104. doi:10.1177/0284185117703153

21. Johannsen AM, Civitarese DM, Padalecki JR, Goldsmith MT, Wijdicks CA, LaPrade RF (2012) Qualitative and quantitative anatomic analysis of the posterior root attachments of the medial and lateral menisci. The American journal of sports medicine 40 (10):2342-2347. doi:10.1177/0363546512457642

22. Lotke PA, Ecker ML (1988) Osteonecrosis of the knee. J Bone Joint Surg Am 70 (3):470-473

23. Asai K, Nakase J, Oshima T, Shimozaki K, Toyooka K, Tsuchiya H (2020) Lateral meniscus posterior root tear in anterior cruciate ligament injury can be detected using MRI-specific signs in combination but not individually. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA 28 (10):3094-3100. doi:10.1007/s00167-019-05599-9

24. Furumatsu T, Kodama Y, Kamatsuki Y, Hino T, Okazaki Y, Ozaki T (2017) Meniscal Extrusion Progresses Shortly after the Medial Meniscus Posterior Root Tear. Knee Surg Relat Res 29 (4):295-301. doi:10.5792/ksrr.17.027

25. Okazaki Y, Furumatsu T, Shimamura Y, Saiga K, Ohashi H, Uchino T, Kamatsuki Y, Okazaki Y, Ozaki T

(2019) Time-Dependent Increase in Medial Meniscus Extrusion after Medial Meniscus Posterior Root Tear Analyzed by Using Magnetic Resonance Imaging. Knee Surg Relat Res. doi:10.5792/ksrr.18.059

Table 1. Demographic and clinical characteristics of the study group

	Positive group	Negative group	P value
Number of patients	34	21	
Sex (male/female)	8/26	5/16	
Age (years)	63.2 ± 9.2	62.9 ± 7.8	> 0.05
Height (m)	1.57 ± 0.1	1.57 ± 0.1	> 0.05
Weight (kg)	62.9 ± 15.4	72.3 ± 19.9	> 0.05
Body mass index (kg/m^2)	25.4 ± 4.3	29.3 ± 7.1	> 0.05
Duration from injury to MRI (weeks)	5.6 ± 7.9	40.9 ± 25.4	< 0.01*
Posterior root tear classification 1/2A/2B/2C/3/4/5	1/6/18/5/0/4/0	2/2/12/2/0/1/0	
PSCL volume (mm^3)	102.0 ± 138.3	N/A	

Data are presented as mean ± standard deviation.

MRI, magnetic resonance imaging; PSCL, posterior shiny-corner lesion; positive group, PSCL positive group; negative group, PSCL negative group.

*Significant difference (P < 0.01) determined using the Mann–Whitney U test.

Table 2. Number of MRI features and sensitivity for MMPRT in all 55cases

		Positive number	Negative number	Sensitivity (%)
All 55 cases	Cleft/truncation sign	31	24	56.3
	Giraffe neck sign	48	7	87.3
	Ghost sign	47	8	85.5
	> 3-mm medial meniscus extrusion	41	14	74.5
	Posterior shiny-corner lesion	34	21	61.8
21 cases	Cleft/truncation sign	7	14	33.3
(within 3 weeks)	Giraffe neck sign	17	4	81.0
	Ghost sign	17	4	81.0
	> 3 mm medial meniscus extrusion	10	11	47.6
	Posterior shiny-corner lesion	19	2	90.5
33 cases	Cleft/truncation sign	14	19	42.4
(within 8 weeks)	Giraffe neck sign	28	5	84.8
	Ghost sign	27	6	81.8
	> 3 mm medial meniscus extrusion	20	13	60.6
	Posterior shiny-corner lesion	27	6	81.8

The sensitivity was calculated using the following formula: (true positive) / (true positive + false negative).

MRI, magnetic resonance imaging; MMPRT, medial meniscus posterior root tear.

Figure legends

Fig. 1 MRI of the left knee taken four days after the popping episode in patients with MMPRT

(a-c) A coronal view showing outstanding PSCL (white arrow) medial from posterior root attachment without apparent giraffe neck sign, cleft/truncation sign, or severe medial extrusion of the MM

(d-f) A sagittal view showing outstanding PSCL (white arrow) posterior from posterior root attachment without apparent ghost sign

MM, medial meniscus; MMPRT, medial meniscus posterior root tear; MRI, magnetic resonance imaging; MTE, medial tibial eminence; PSCL, posterior shiny corner lesion

Fig. 2 Comparison of duration from injury to the time of MRI. Significant difference in duration from injury to the time of MRI was observed between PSCL positive and negative groups. *, $P < 0.01$

MRI, magnetic resonance imaging; PSCL, posterior shiny corner lesion

Fig. 3 Consecutive MRI of the left knee in patients with MMPRT

(a, b) Images taken 3 days after MMPRT showing outstanding PSCL (white arrow) with slight giraffe neck sign (dotted area) and without cleft sign

(c, d) Images taken 56 days after MMPRT showing no apparent PSCL with giraffe neck sign (dotted area) and cleft sign (white arrowhead)

MMPRT, medial meniscus posterior root tear; MRI, magnetic resonance imaging; PSCL, posterior shiny corner

lesion

Figure

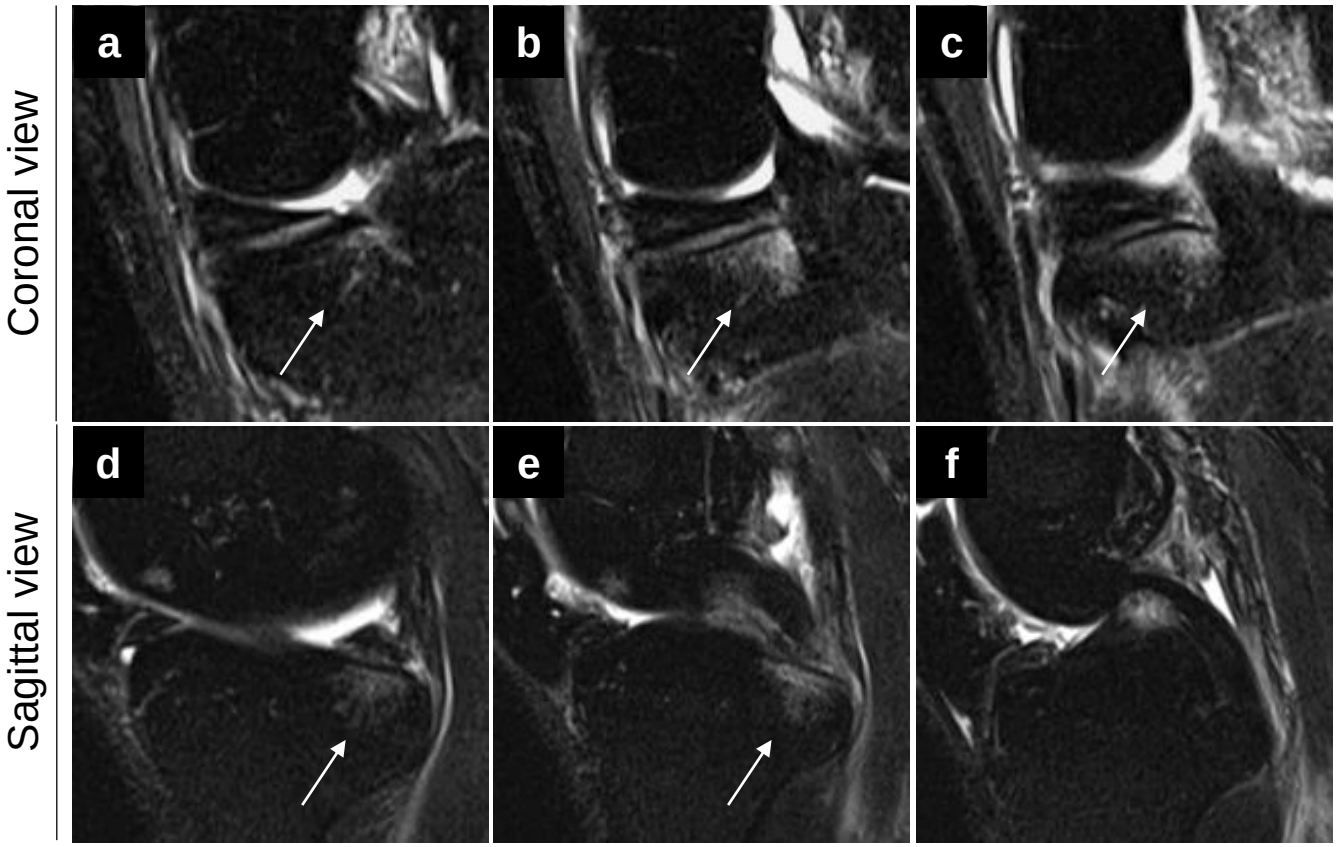

Fig.1

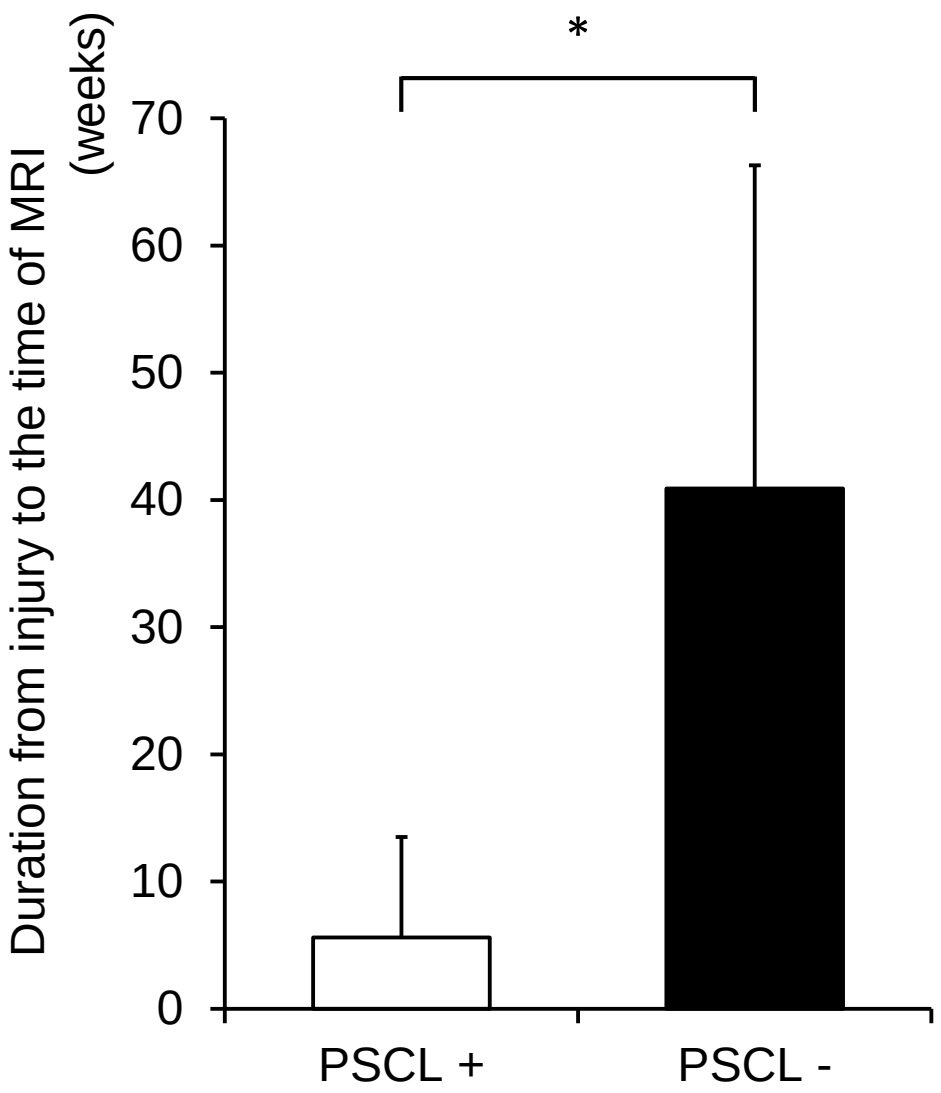
*
Duration from injury to the time of MRI (weeks)
70
60
50
40
30
20
10
0
PSCL +
PSCL -

Fig.2

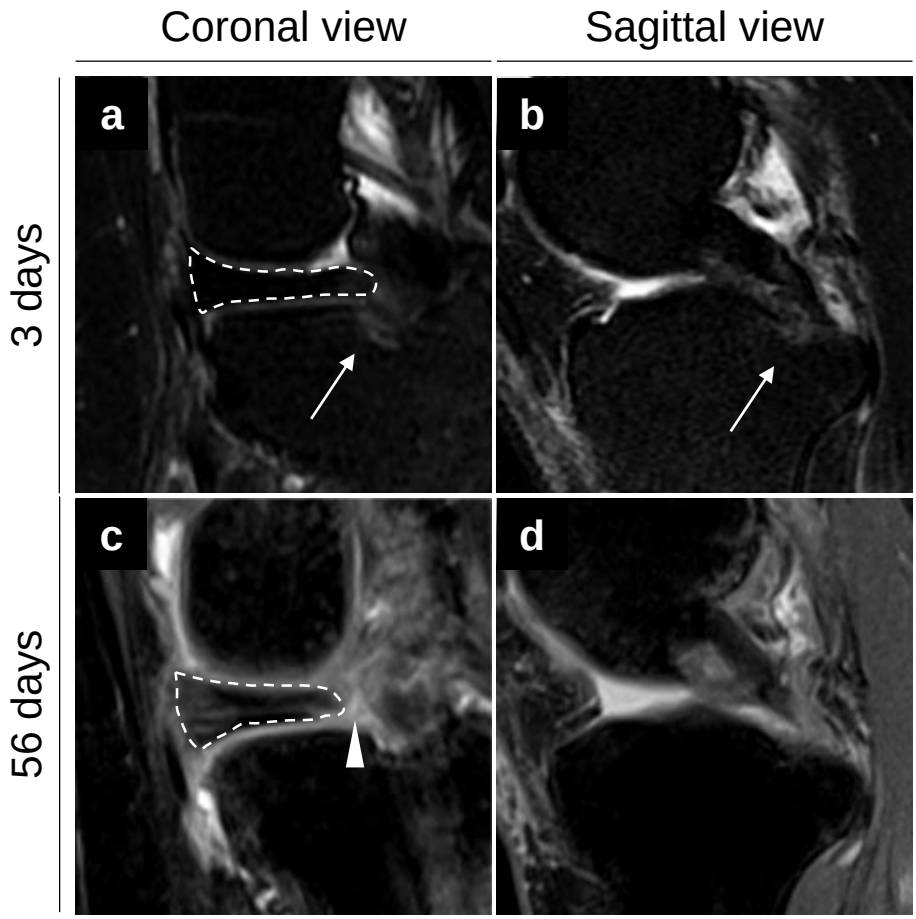

Fig.3

A posterior shiny-corner lesion of the tibia is observed in the early phase after medial meniscus posterior root tear

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Abstract

Background: Medial meniscus (MM) posterior root tear (PRT) results in joint overloading and degenerative changes in the knee, and pullout repair is recommended to prevent subsequent osteoarthritis. Diagnosing MMPRT is sometimes difficult, especially in the case of an incomplete tear. A posterior shiny-corner lesion (PSCL) is reported to be useful for diagnosis, although the association between MMPRT and PSCL is unknown. This study aimed to investigate the properties of PSCL, such as the location, volume, and duration from injury to the time of MRI (duration). We hypothesized that PSCL is observed in the early phase after the MMPRT onset.

Methods: T2-weighted fat-suppression MRI was obtained from 55 patients with MMPRT preoperatively. The prevalence of the PSCL; giraffe neck, cleft, and ghost signs; severe MM extrusion (>3 mm); and the PSCL volume were evaluated. The PSCL lesion elliptical volume (mm^3) was calculated by measuring the anteroposterior, transverse, and craniocaudal dimensions.

Results: PSCL was observed in 34 (62%) cases. The mean volume of the PSCL was 102.0 mm^3. A significantly shorter duration was observed in the PSCL positive group (5.6 weeks) than that in the PSCL-negative group (40.9 weeks, $P<0.01$), although no significant correlation was observed between the PSCL volume and duration. The sensitivity for the MMPRT was 90.5% when the cutoff duration value was 3 weeks and 81.8% when the cutoff value was 8 weeks.
Conclusions: MRI examination may detect PSCL if it is performed early following MMPRT onset. Detecting PSCL may be useful in diagnosing MMPRT with high sensitivity.

Keywords: posterior shiny-corner lesion, medial meniscus, posterior root tear, magnetic resonance imaging, diagnosis, sensitivity

Declarations

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