


RESEARCH ARTICLE

Open Access



Evaluation of morphological characteristics for incomplete discoid medial meniscus with an oversized posterior segment

Shotaro Araki¹, Masanori Tsubosaka², Hirotsugu Muratsu^{1*} , Takao Inokuchi¹, Hiroaki Maruo¹, Hidetoshi Miya¹, Ryosuke Kuroda² and Takehiko Matsushita²

Abstract

Background: A discoid medial meniscus is rare in comparison with a discoid lateral meniscus. We encountered a new type of incomplete discoid with an oversized posterior segment. Therefore, this study aimed to report cases of medial meniscus with an oversized posterior segment and analyze the morphological characteristics by comparing them to cases with a discoid medial meniscus and normal medial meniscus.

Methods: Four patients with an oversized posterior segment medial meniscus (oversize group, mean age: 25.3 ± 12.0 years) and seven patients with a discoid medial meniscus (discoid group, mean age: 34.4 ± 19.6) were identified using magnetic resonance imaging (MRI) and diagnosed by arthroscopic findings in our hospital. Fifty patients without medial meniscal injury were retrospectively selected as the normal group (normal group, mean age: 24.0 ± 11.3 years). The clinical symptoms were examined. The anteroposterior (AP) length of both the anterior and posterior segments, AP length ratio of the posterior segment to the AP length of the medial tibial plateau, and mediolateral (ML) width of the mid-body of the medial meniscus were also evaluated using MRI and compared among the three groups.

Results: All patients in the oversize group complained of medial knee pain during deep knee flexion. In sagittal MRI, posteriorly deviated indentations were also observed at the medial tibial plateau in all cases in the oversize group. There was a significant difference in the AP length of the posterior segment between the normal and oversize groups (14.3 ± 2.8 vs. 23.6 ± 2.8 mm, $P < 0.001$), whereas there was no significant difference in the AP length of the anterior segment (9.1 ± 2.1 vs. 9.5 ± 1.9 mm, $P = 0.869$). The ML width of the mid-body in the normal, oversize, and discoid groups was 9.3 ± 1.8 , 19.9 ± 2.6 , and 25.8 ± 1.9 mm, respectively (normal vs. oversize group: $P < 0.001$, oversize vs discoid group: $P = 0.01$, normal vs. discoid group: $P < 0.001$).

Conclusions: Oversized posterior and normal anterior segments characterize this new type of incomplete discoid medial meniscus as a morphological abnormality.

Keywords: Medial meniscus, Discoid, Oversize posterior segment, Morphological characteristic

Background

The discoid medial meniscus, first reported by Cave and Staples in 1941 [1], is exceedingly rare compared to the discoid lateral meniscus [2–5]. The incidence of the discoid medial meniscus is as low as 0.12% [6], whereas that

*Correspondence: hiromuratsu@gmail.com

¹ Department of Orthopaedic Surgery, Steel Memorial Hirohata Hospital, 3-1 Yumesaki-chou Hirohata-ku, Himeji-City, Hyogo 671-1122, Japan
Full list of author information is available at the end of the article



of the discoid lateral meniscus ranges from 0.4% to 17% [7–13].

Discoid meniscal tears occur in relatively younger patients. Generally, discoid medial meniscus symptoms often appear according to the symptoms of meniscal tears, and the symptoms do not occur only in the presence of the discoid meniscus [14]. The clinical symptoms of discoid medial meniscus include swelling, pain in the knee joint, and clicking. The symptoms, although relatively mild, worsen due to the progression of meniscal injury. Therefore, the discoid medial meniscus is often discovered after the meniscus is injured, and these patients are surgically treated with arthroscopic discoid meniscectomy [15–17].

The complete type, which covers the entire articular surface of the medial tibial plateau, has been described in previous reports on the discoid medial meniscus [3–5, 18]. A complete discoid meniscus can be diagnosed on sagittal magnetic resonance imaging (MRI), showing continuity between the anterior and posterior horns of the meniscus in three consecutive cuts. Kocher et al. reported that further confirmation could be obtained with the coronal images showing a transverse meniscal diameter > 15 mm or an involvement of > 20% of the tibial width [19]. However, the incomplete medial discoid type has not been mentioned in previous reports.

We encountered four rare cases of a medial meniscus with a larger posterior segment than the normal medial meniscus, but normal anterior segment. The purpose of this study was to report “this subtype discoid medial meniscus” including case reports and analyze the morphological characteristics in comparison with discoid medial menisci and normal menisci.

Methods

This study was approved by the Institutional Ethics Review Committee. Between 2006 and 2018, four patients with an oversized posterior segment medial meniscus (oversize group, mean age: 25.3 ± 12.0 years, three men and one woman) and seven patients with discoid medial meniscus (discoid group, mean age: 34.4 ± 19.6 years, five men and two women) were identified using magnetic resonance imaging (MRI) and diagnosed by arthroscopic findings in our hospital. A total of 50 patients with an isolated anterior cruciate ligament injury without medial meniscus injury were retrospectively selected as the normal group between 2015 and 2018 (normal group, mean age: 24.0 ± 11.3 years, 25 men and 25 women).

Standing anteroposterior and lateral radiographs of the knee were obtained for all the patients on their first visit to our hospital. The meniscal morphology and type of tear were evaluated with MRI using fat suppression T2 weighted imaging. The axial magnetic resonance

images were sliced perpendicular to the tibial axis; coronal images were sliced parallel to the connecting line between the medial and lateral condyles of the femur; and sagittal images were sliced perpendicular to the line between the connecting line between the medial and lateral condyles of the femur. The slice width on MRI was 3 mm.

MRI measurements

The anteroposterior (AP) lengths of the anterior and posterior segments of the medial meniscus were measured using the sagittal image at the midpoint of the medial tibial plateau between the medial edge and tip of the medial intercondylar eminence (Fig. 1A ab, B). The mediolateral (ML) width of the mid-body was measured on the coronal image, which was sectioned at the midpoint of the AP length of the medial tibial plateau (Fig. 1A ac, B). The AP length ratio of the posterior segment relative to the medial tibial plateau was calculated. If the AP length of the posterior segment of the medial meniscus exceeded 19.9 mm, we named the menisci with large posterior segments as “oversize posterior segment medial meniscus.”

In the discoid group, only the ML width of the mid-body was measurable because we could not identify both the anterior and posterior segments (Fig. 1B). The AP lengths of the anterior and posterior segments were compared between the oversize and normal groups. The ML widths of the mid-body were compared between the oversize, discoid, and normal groups.

Statistical analysis

Statistical analyses were performed using StatView software 5.0 (Abacus Concepts, Berkeley, CA, USA). Comparisons between the two groups were made using the Mann–Whitney U test. The Kruskal–Wallis test was used for comparison among the three groups, and the Bonferroni–Dunn method was used for post hoc analysis. All the tests were two-tailed with a confidence level of 95% ($P < 0.05$). The values are expressed as the mean \pm standard deviation.

Results

The demographic data of the three groups are shown in Table 1. All the patients, including those in the oversize and discoid groups, experienced pain in the knee joint. However, especially in the oversize group, pain with deep knee flexion was observed in all patients on physical examination. Conversely, three patients (42.9%) in the discoid group complained of deep flexion pain. Catching/clicking was observed in approximately 50% of the patients in both groups.

Widely spread horizontal tears were observed on MRI in all the patients in the oversize group. On lateral

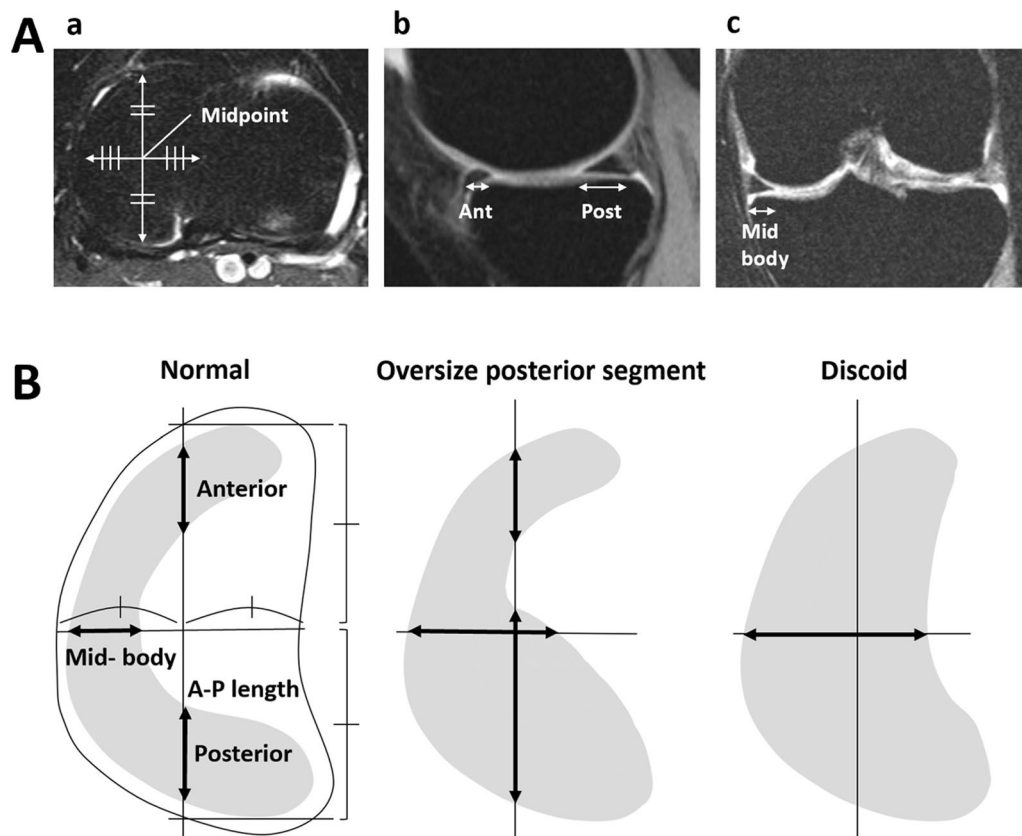
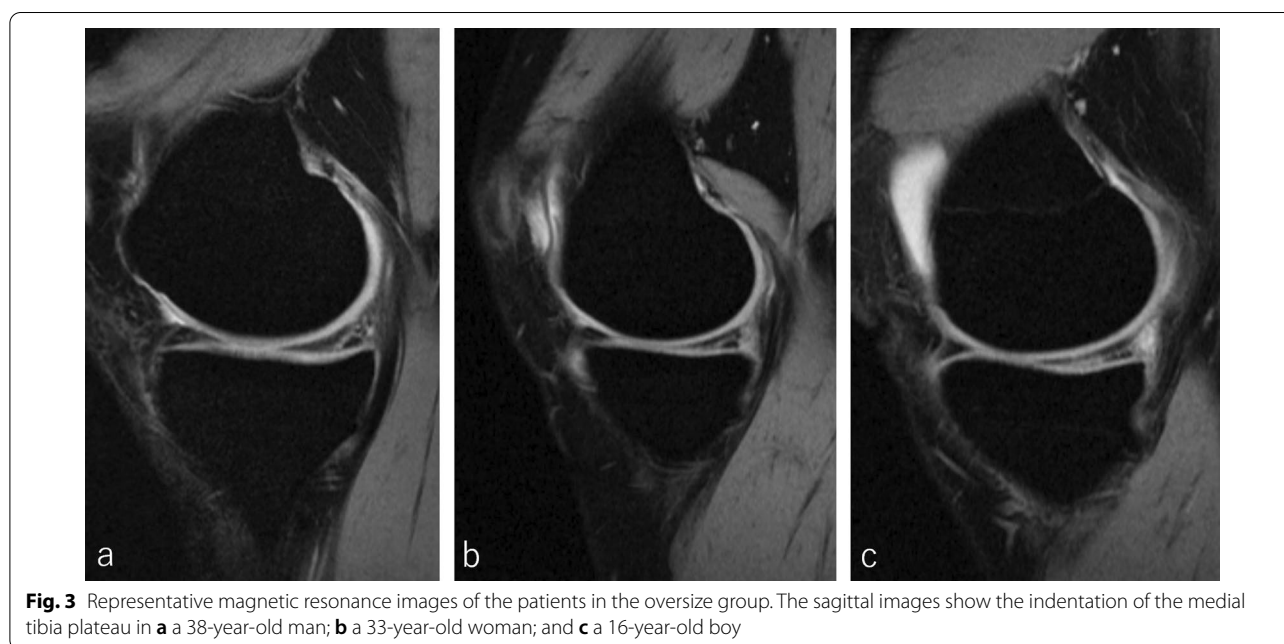
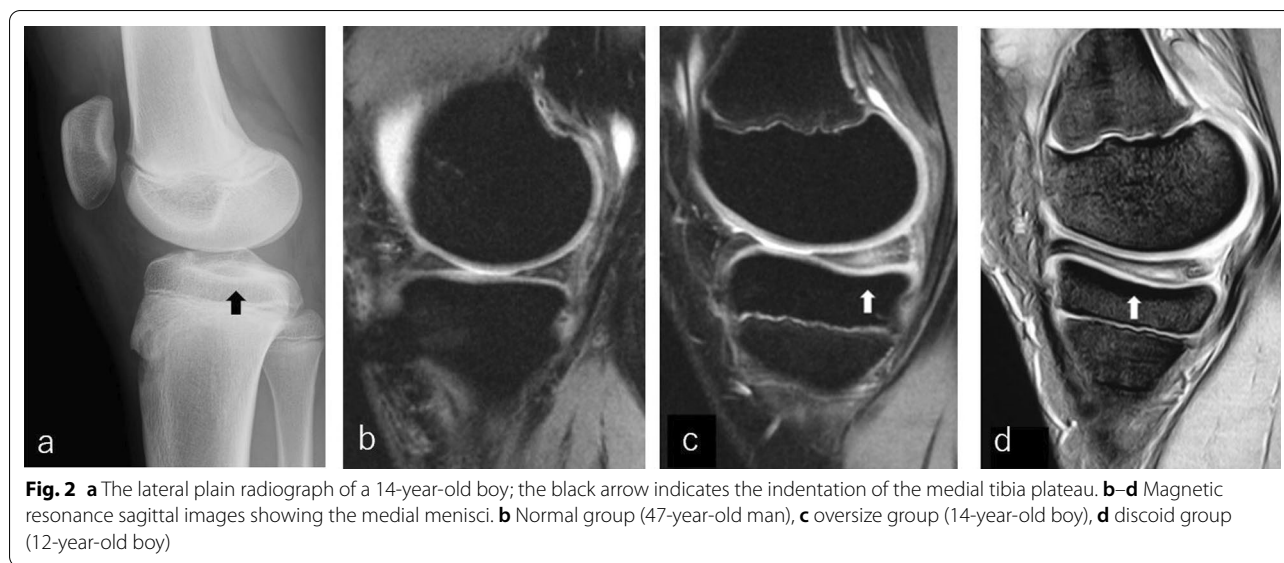


Fig. 1 **A** Measurement methods in magnetic resonance imaging. (a) An axial view at the medial meniscus level. (b) The anteroposterior (AP) length of the medial meniscus is measured on sagittal-view images sectioning the midpoint between the medial edge of the tibia and the medial intercondylar eminence. (c) The mediolateral (ML) width of the medial meniscus is measured on the coronal-view images sectioning the midpoint of the AP width of the medial tibial plateau. **B** Illustrations showing the measurements in the normal, oversize, and discoid groups

Table 1 Demographic data

	Normal	Oversize	Discoid	P value
Gender				
Male	25	3	5	–
Female	25	1	2	
Mean age (years) (range)	24.1 ^a (8–54)	25.3 ^b (14–38)	34.4 ^c (12–68)	a,b, <i>p</i> = 0.933 b,c, <i>p</i> = 0.352 c,a, <i>p</i> = 0.275
BMI (range)	23.0 ^a (17.7–33.5)	19.6 ^b (17.6–21.4)	21.7 ^c (15.0–26.0)	a,b, <i>p</i> = 0.023 b,c, <i>p</i> = 0.171 c,a, <i>p</i> = 0.801
Pain with deep knee flexion	–	4/4	3/7	–
Catching and click	–	2/4	4/7	–
Tear pattern	–	Horizontal (4/4)	Horizontal (3/7) + Complex (4/7)	–
Position of tibial indentation	–	Posteriorly (4/4)	Central (6/7)	–



radiographs and sagittal MRI, the indentations of the medial tibial plateau were observed posteriorly in all cases (Figs. 2a, c, 3) (Table 1). Three patients with mild symptoms in the contralateral knee underwent MRI scans, and all patients had a medial meniscus with an oversized posterior segment bilaterally.

Arthroscopic examination revealed that the oversized posterior segment covered the posterior half of the medial tibial plateau and the anterior segment appeared normal. Articular surface indentation of the

medial tibial plateau was observed in the posterior portion, corresponding to the oversized posterior segment in all cases (Figs. 4, 5). All patients underwent partial meniscectomies. All patients experienced pain relief after the surgery (Figs. 4d, 5d).

MR measurements

The measurement data for the three groups are listed in Table 2. There was a significant difference in the AP length of the posterior segment between the oversized and

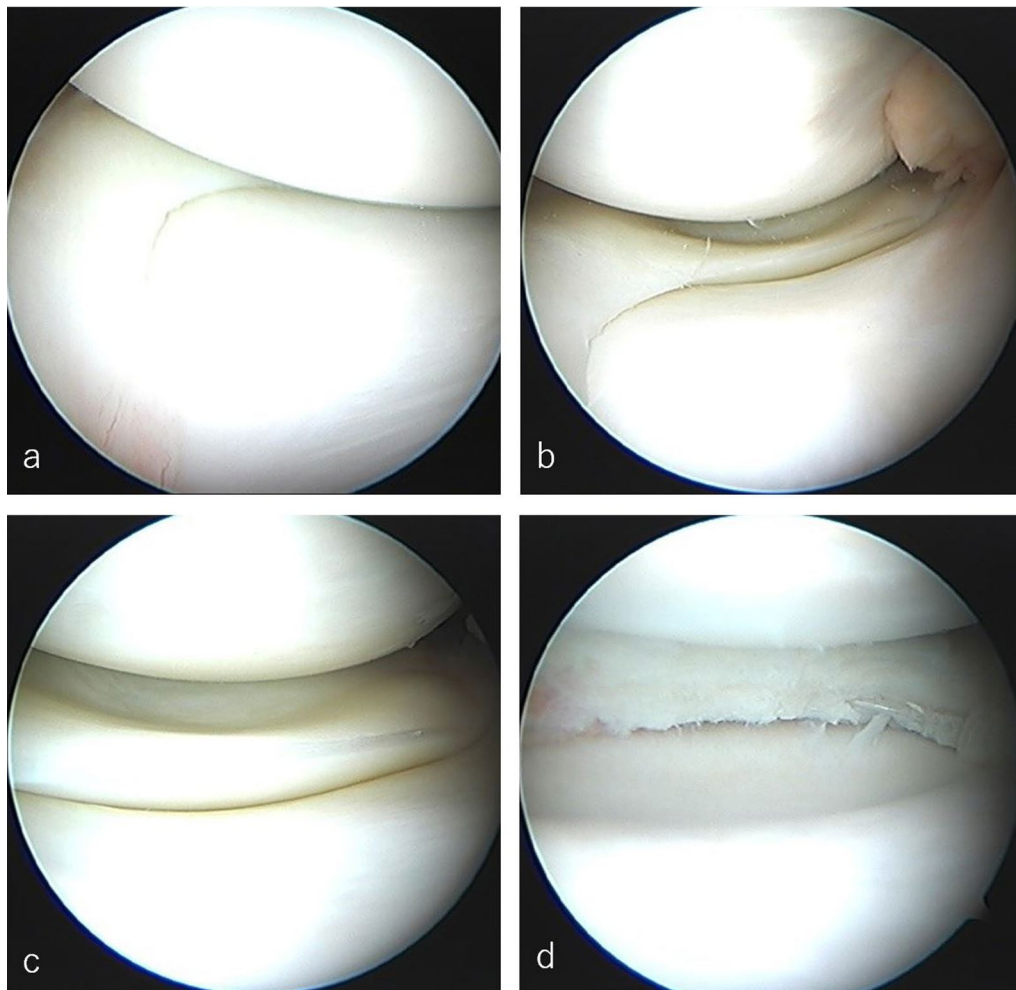


Fig. 4 Arthroscopic views of the oversized posterior segment medial meniscus (from the anterolateral portal) of a 14-year-old boy. **a** Normal anterior segment medial meniscus. **b** The mid-body and oversized posterior segment. **c** The oversized posterior segment. **d** Post-partial meniscectomy

normal groups ($P < 0.001$). In contrast, no significant differences were observed in the AP lengths of the anterior segment.

There were significant differences in the mid-body ML width in the normal, oversized, and discoid groups. The mid-body width of the discoid group was the largest among the three groups. The mid-body ML width in the overweight group was significantly larger than that in the normal group ($P = 0.010$).

Discussion

The most important finding of this study was that we found a new type of morphological abnormality of the medial meniscus. Although there are some reports on the embryology of the discoid meniscus [20–23], this remains largely unclear. Evidence suggests that the meniscus becomes a clearly defined structure by the 8th

week of fetal development. The meniscus assumes its relationship with the rest of the knee by the 14th week [24]. Fukazawa et al. reported that the discoid shape is established postnatally due to hypertrophy of the meniscus following lesions caused by detachment of the posterior portion of the meniscus from the tibial plateau [25]. This report presents a new incomplete type of discoid medial meniscus with an oversize posterior segment, which has never been reported previously.

Significantly larger sizes characterized the abnormal morphology of the oversized posterior segment medial meniscus at the mid-body and posterior segment, without a significant difference at the anterior segment compared to the normal group. Previous reports of a discoid medial meniscus pointed out “cupping” [26, 27] of the medial tibial plateau on AP radiographs and the central indentation of the medial tibial plateau on

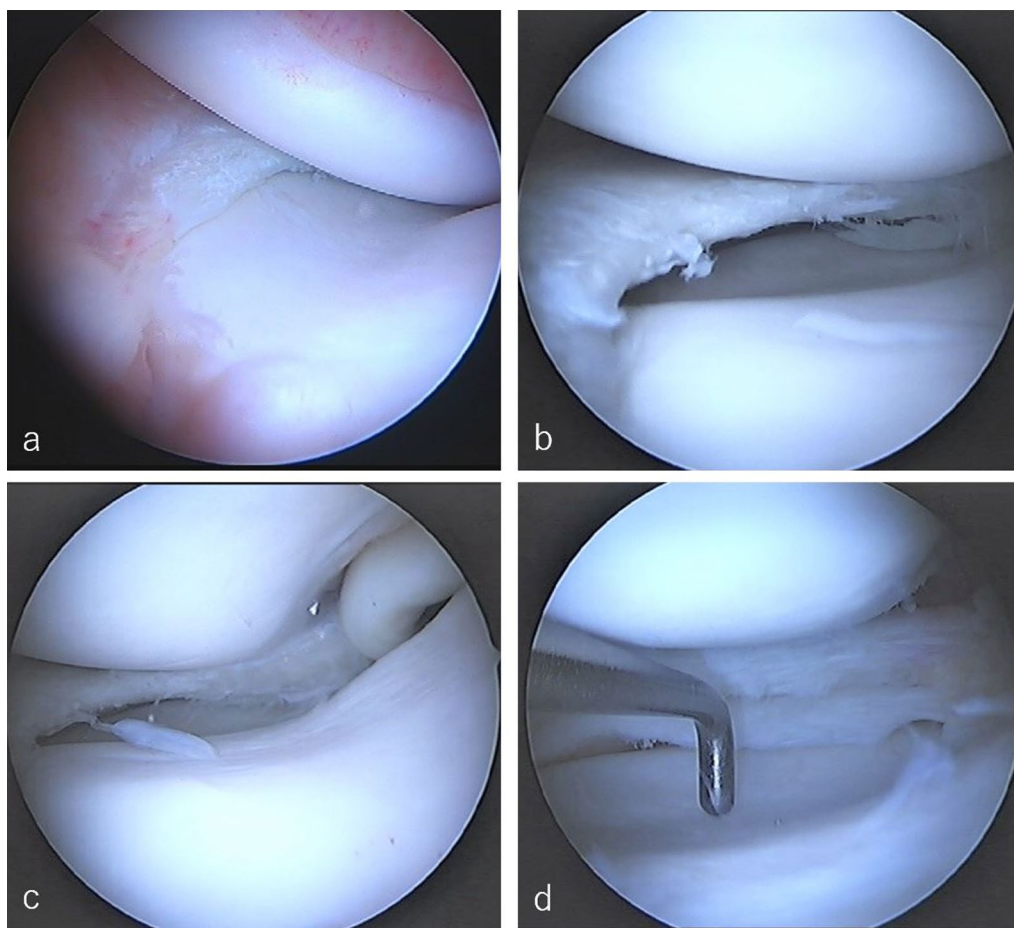


Fig. 5 Arthroscopic views of the oversized posterior segment medial meniscus (from the anterolateral portal) of a 16-year-old boy. **a** Normal anterior segment medial meniscus and synovial hyperplasia. **b** The mid-body and oversized posterior segment. **c** Incarceration of the oversized posterior segment medial meniscus in the intercondylar fossa. **d** Post-partial meniscectomy

Table 2 MR measurement

	Normal (n = 50)	Oversize (n = 4)	Discoid (n = 7)	Statistics
AP length of the anterior segment (mm)	9.1 ± 2.1 (4.7–13.6)	9.5 ± 1.9 (8.0–12.2)	N/A	n.s
ML width of the mid-body (mm)	9.3 ± 1.8 ^a (5.9–13.3)	19.9 ± 2.6 ^b (16.1–21.6)	25.8 ± 1.9 ^c (25.5–27.8)	a,b, P < 0.001 b,c, P = 0.010 c,a, P < 0.001
AP length of the posterior segment (mm)	14.3 ± 2.8 (8.2–19.3)	23.6 ± 2.8 (20.0–26.5)	N/A	P < 0.001
AP length ratio	0.30 ± 0.05 (0.17–0.40)	0.48 ± 0.05 (0.43–0.52)	N/A	P < 0.001

Data are presented as mean ± standard deviation (range). N/A Not applicable. n.s. no statistically significant difference

sagittal MRI as characteristic imaging findings [28]. Similar to previous reports, all patients with discoid and oversized posterior segment medial menisci in our study indicated indentation of the medial tibial plateau on lateral radiographs and sagittal MRI. Moreover, we found a difference in the location of the indentation between patients with discoid and oversized posterior

menisci. In patients with discoid menisci, indentations were observed near the center of the medial plateau, whereas they were observed in the posterior area in the oversized posterior segment of the medial menisci (Fig. 2b–d).

The medial meniscus is mainly C-shaped, and various shapes of the medial meniscus have been reported, and

morphometry of the medial meniscus is also reported [22, 23]. Bloecker et al. reported morphometric differences between the medial and lateral menisci by three-dimensional analysis using MRI [29]. These results were similar in width to the anterior, mid-body, and posterior segments, measured as a normal group at our hospital. In our study, if the AP length of the posterior segment of the medial meniscus exceeded 19.9 mm, the patients were defined as those with an oversized posterior segment. The ML widths of the mid-body were < 14 mm in the normal group, 16–22 mm in the oversize group, and > 25 mm in the discoid group. A significant difference was observed between the normal and oversize groups. In contrast to the posterior and mid-body segments, there were no differences in the anterior segment between the oversize and normal groups (< 14 mm in both groups). Therefore, the oversize posterior segment medial meniscus could be defined with an abnormally oversize posterior segment (≥ 20 mm) and normal anterior segment size (< 14 mm). In addition to the normal size of the anterior segment, the lower ML width of the mid-body could be a possible parameter for distinguishing the oversized posterior segment from the discoid medial meniscus. However, the size of the meniscus is likely to change with sex, age, height, and weight, etc. One report stated that the meniscus size correlated more strongly with the size of the tibial plateau [30]. Therefore, we calculated the AP length ratio of the posterior segment relative to the medial tibial plateau and found a significant difference in the AP length ratio between the oversize group and the normal group (Table 2) (0.48 vs 0.30, $P < 0.001$).

For the classification of discoid lateral menisci, complete, incomplete, and Wrisberg types are often used [7, 31]. Regarding the shape of the discoid lateral meniscus, the central part of the meniscus was smaller and thinner in incomplete discoid lateral menisci than in complete discoid menisci. Notably, medial menisci with oversized posterior segments in our study had larger middle to posterior segments than those with normal medial menisci. The shapes appeared different from the incomplete type, but resembled the Wrisberg-type lateral discoid menisci. Although the oversized posterior segment medial meniscus could be regarded as an “incomplete type of discoid medial meniscus,” we specifically named it as “oversize posterior segment” to clarify the characteristics of this new morphological abnormality in the medial meniscus. Moreover, none of the patients in our study had meniscal anomalies of “abnormal anterior horn insertion on the ACL” [32–34] and “meniscal cyst,” which were reported as coexisting abnormalities with the discoid medial meniscus [35]. Therefore, none of the patients with oversized posterior segment had a discoid medial meniscus characteristic in this study. To the best

of our knowledge, there have been no previous reports of incomplete discoid medial menisci and/or oversized posterior segments. Therefore, this report is the first to identify a new type of abnormality of the medial meniscus as an incomplete discoid medial meniscus. We also identified the clinical features of oversized posterior-segment medial menisci. All the patients started experiencing medial knee pain without obvious trauma or strenuous sports, as often observed in patients with discoid lateral and discoid medial menisci [14]. Therefore, if clinicians encounter relatively younger patients who begin having medial pain without any cause and have a wide, severe horizontal tear in the posterior segment, an oversized-posterior-segment medial meniscus can be considered a possible etiology.

This study has some limitations. First, the number of cases with oversized posterior segments was small. As there were four cases, there is a possibility that measurement errors may have increased, and there may be less reliability of the clinical symptoms and imaging findings. Therefore, it is necessary to conduct future studies with a larger number of cases. Second, there is a possibility that there may have been measurement errors because we used MRI for measurements. Thirdly, there is a potential for bias in the measurement of meniscus sizes. Therefore, the measurements were taken twice by two examiners. The intra-class correlation coefficients (ICC) were excellent for all measurements, showing that the measure was reliable (intra: 0.92, inter: 0.90). Finally, although an oversize posterior segment characterized this new type of incomplete discoid medial meniscus as the morphological abnormality, we could not find clearly clinical significance in this study. However, the incomplete discoid medial meniscus with an oversize posterior segment did not have the morphological features that should be in the discoid. In particular, the incomplete discoid medial meniscus was characterized by the normal anterior segment. We believe that this clearly distinguishes it from the discoid meniscus. Therefore, further research would be required to characterize better the epidemiology of this new type of incomplete discoid meniscus, establish diagnostic methods other than MRI, and provide specific surgical treatment.

Conclusions

We investigated the clinical characteristics and MRI findings in 11 patients, including 4 with oversized posterior segments and 7 with discoids of the medial menisci. A relatively younger age, subtle symptoms, and sagittal joint surface geometries of the medial tibial plateau were characteristic in these patients. Posterior and center indentations were observed in oversized posterior segment and

discoid cases, respectively. An incomplete discoid medial meniscus with an oversized posterior segment meniscus can be defined as a new type of morphological abnormality in the medial meniscus.

Abbreviations

MRI: Magnetic resonance imaging; AP: Anteroposterior; ML: Mediolateral.

Acknowledgements

We would like to thank Editage (www.editage.com) for English language editing. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors contributions

All authors have made substantial contributions to (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; and (3) final approval of the version to be submitted. The specific contributions of the authors are as follows: (1) SA, MT, TM, HM helped in conception and design of the study and drafting of the article. (2) All authors contributed to analysis and interpretation of the data. (3) All authors were involved in final approval. All authors read and approved the final manuscript.

Funding

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Steel Memorial Hirohata Hospital and conducted according to the guidelines (Management Department No. 30-135).

Consent for publication

The study design was approved by institutional ethics review board.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Orthopaedic Surgery, Steel Memorial Hirohata Hospital, 3-1 Yumesaki-chou Hirohata-ku, Himeji-City, Hyogo 671-1122, Japan. ²Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan.

Received: 30 September 2021 Accepted: 12 April 2022

Published online: 20 April 2022

References

- Cave EF, Staples OS. Congenital discoid meniscus: A cause of internal derangement of the knee. *Am J Surg.* 1941;54:371–6.
- Abhay GN, Ashwin S, Sunil S, Hardik K. Arthroscopic meniscectomy and meniscoplasty for a torn discoid medial meniscus: case report, surgical technique, and literature review. *J Orthop Case Rep.* 2016;6:84–7.
- Song IS, Kim JB, Lee JK, Park B-S. Discoid medial meniscus tear, with a literature review of treatments. *Knee Surg Relat Res.* 2017;29:237–42.
- Sevillano-Perez E, Espejo-Reina A, Espejo-Reina MJ. Symptomatic bilateral torn discoid medial meniscus treated with saucerization and suture. *Case Rep Orthop.* 2016;2016:1–6.
- Yang X, Shao D. Bilateral discoid medial Meniscus: two case reports. *Med (United States).* 2019; 98.
- Dickason JM, Del Pizzo W, Blazina ME, Fox JM, Friedman MJ, Snyder SJ. A series of ten discoid medial menisci. *Clin Orthop Relat Res.* 1982;168:75–9.
- Fukuta S, Masaki K, Korai F. Prevalence of abnormal findings in magnetic resonance images of asymptomatic knees. *J Orthop Sci.* 2002;7:287–91.
- Kim SJ, Lee YT, Kim DW. Intraarticular anatomic variants associated with discoid meniscus in Koreans. *Clin Orthop Relat Res.* 1998; 202–7.
- Rao PS, Rao SK, Paul R. Clinical, radiologic, and arthroscopic assessment of discoid lateral meniscus. *Arthroscopy.* 2001;17:275–7.
- Papadopoulos A, Karathanasis A, Kirkos JM, Kapetanios GA. Epidemiologic, clinical and arthroscopic study of the discoid meniscus variant in Greek population. *Knee Surg Sports Traumatol Arthrosc.* 2009;17:600–6.
- Kim J-G, Han S-W, Lee D-H. Diagnosis and treatment of discoid meniscus. *Knee Surg Relat Res.* 2016;28:255–62.
- Sabbag OD, Hevesi M, Sanders TL, Camp CL, Dahm DL, Levy BA, et al. Incidence and treatment trends of symptomatic discoid lateral menisci: An 18-year population-based study. *Orthop J Sport Med.* 2018;6:1–6.
- Yaniv M, Blumberg N. The discoid meniscus. *J Child Orthop.* 2007;1:89–96.
- De WH, Li T, Gao SJ. Improved arthroscopic one-piece excision technique for the treatment of symptomatic discoid medial meniscus. *J Orthop Surg Res.* 2017;12:1–7.
- Kim SJ, Yoo JH, Kim HK. Arthroscopic one-piece excision technique for the treatment of symptomatic lateral discoid meniscus. *Arthroscopy.* 1996;12:752–5.
- Lee BI, Choi HS. Arthroscopic treatment of symptomatic discoid lateral meniscus in a 26-month-old girl. *Arthroscopy.* 2003;19:1133–6.
- Ogata K. Arthroscopic technique: two-piece excision of discoid meniscus. *Arthroscopy.* 1997;13:666–70.
- Wang H De, Gao SJ. Bilateral discoid medial meniscus associated with meniscal tears and hypoplasia of the medial femoral condyle: a case report. *Med (United States).* 2017; 96: 0–4.
- Kocher MS, Klingele K, Rassman SO. Meniscal disorders: Normal, discoid, and cysts. *Orthop Clin N Am.* 2003;34:329–40.
- Smillie IS. The congenital discoid meniscus. *J Bone Jt Surg Br.* 1948; 30B: 671–682.
- Kaplan EB. Discoid lateral meniscus of the knee joint; nature, mechanism, and operative treatment. *J Bone Joint Surg Am.* 1957; 39: 77–87.
- Koyuncu E, Özgüner G, Öztürk K, Bilkay C, Dursun A, Sulak O. The morphological anatomy of the menisci of the knee joint in human fetuses. *Balkan Med J.* 2017;34:559–66.
- Murlimanju BV, Nair N, Pai MM, Krishnamurthy A, Philip CX. Morphology of the medial meniscus of the knee in human fetuses. *Rom J Morphol Embryol.* 2010;51:347–51.
- Andrish JT. Meniscal injuries in children and adolescents: diagnosis and management. *J Am Acad Orthop Surg.* 1996;4(5):231–7.
- Fukazawa I, Hatta T, Uchio Y, Otani H. Development of the meniscus of the knee joint in human fetuses. *Congenit Anom (Kyoto).* 2009;49:27–32.
- Song W, Choi J, Kim T, Kim T, Oh S. A bilateral discoid medial meniscus with symptomatic intrasubstance cleavage tear. *Arthrosc Orthop Sport Med.* 2014;1:46–9.
- Weiner B, Rosenberg N. Discoid medial meniscus: association with bone changes in the tibia. A case report. *J Bone Jt Surg Am.* 1974; 56: 171–173.
- Atay OA, Doral MN, Aydingöz U, Leblebicioglu G. Bilateral discoid medial menisci: association with bone changes in the tibia. *Knee Surg Sports Traumatol Arthrosc.* 2001;9:217–20.
- Bloecker K, Wirth W, Hudelmaier M, Burgkart R, Frobell R, Eckstein F. Morphometric differences between the medial and lateral meniscus in healthy men—a three-dimensional analysis using magnetic resonance imaging. *Cells Tissues Organs.* 2012;195:353–64.
- Bloecker K, Englund M, Wirth W, Hudelmaier M, Burgkart R, Frobell RB, et al. Revision 1 Size and position of the healthy meniscus, and its correlation with sex, height, weight, and bone area—a cross-sectional study. *BMC Musculoskelet Disord.* BioMed Central Ltd; 2011; 12: 248.
- Watanabe M, Takada S, Ikeuchi H. 2nd ed. *Igaku-Shoin*; Tokyo: 1969. *Atlas of Arthroscopy*; p. 122.

32. Narvekar A, Acharya A, Shroff M. Bilateral discoid medial menisci with abnormal attachment to the anterior cruciate ligament —a case report. *Acta Orthop Scand*. 1999;70:387–9.
33. Flouzat-Lachaniette CH, Pujol N, Boisrenoult P, Beaufils P. Discoid medial meniscus: Report of four cases and literature review. *Orthop Traumatol Surg Res*. Elsevier Masson SAS; 2011; 97: 826–32. <https://doi.org/10.1016/j.otsr.2011.07.011>
34. Jung YB, Yum JK, Bae YJ, Song KS. Anomalous insertion of the medial menisci. *Arthroscopy*. 1998;14:505–7.
35. Kim SJ, Choi CH. Bilateral complete discoid medial menisci combined with anomalous insertion and cyst formation. *Arthroscopy*. 1996;12:112–5.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

