



Symptomatic discoid lateral meniscus shows a relationship between types and tear patterns, and between causes of clinical symptom onset and the age distribution

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Abstract

Purpose Discoid meniscus is a congenital abnormality of the lateral meniscus and is seen more frequently in East Asia. The purpose of this study was to retrospectively assess the relationship between discoid lateral meniscus (DLM) types and tear patterns and causes of age-specific clinical symptom onset.

Methods Of 1650 arthroscopic surgeries over a 20-year period, 138 (105 patients) were performed for DLM and were evaluated in this study. The mean age at surgery was 21.5 ± 15.8 years. The DLM type was classified by Watanabe's classification, and tear patterns were classified by the modified Bin's classification as simple horizontal, complicated horizontal, longitudinal, radial, complex, and no tear. Additionally, patients were divided by age group (< 10, 10–19, 20–39, 40–59, and ≥ 60 years) and classified according to the causes of clinical symptom onset as follows: sports activities, minor trauma in daily living, and no traumatic episode.

Results The DLM was complete in 78 (56.5%) knees and incomplete in 60 (43.5%); no Wrisberg type DLM was observed. Simple horizontal and complicated horizontal tears were significantly more frequent in complete DLM, whereas radial tears and no tears were significantly more frequent in incomplete DLM ($p < 0.0001$). When classified by age group, 74 (53.6%) knees with DLMs were found in teenagers. Sports activities caused symptom onset significantly more often in teenagers, no traumatic episode caused symptom onset in patients aged < 10 years, and minor trauma in daily living caused symptom onset in patients aged 40–59 years and ≥ 60 years ($p < 0.0001$). No relationship was found between the age distribution and tear patterns; however, the absence of tears tended to be more common in teenaged patients, and complicated horizontal tears were more common in patients over 20 years of age.

Conclusion Symptomatic DLM occurred most often in teenagers. A relationship was identified between the DLM types and tear patterns, which could be helpful in preoperative planning. Causes of clinical symptom onset in patients with DLM were characterised by age group, which might help clinicians to suspect the presence of DLM.

Level of evidence Level IV.

Keywords Discoid lateral meniscus · Type · Tear pattern · Clinical symptom onset · Age distribution

Abbreviations

DLM Discoid lateral meniscus
MRI Magnetic resonance imaging
n.s. Not significant

Introduction

Discoid meniscus is a well-known abnormality of the lateral meniscus of the knee that was first reported by Young in 1889 [47]. Discoid lateral meniscus (DLM) is sometimes discovered incidentally during an arthroscopic procedure or by magnetic resonance imaging (MRI); the incidence ranges from 0.4 to 17% [16]. A discoid medial meniscus is very rare, with an incidence of 0.12% as reported by Dickason et al. [11] and 0.06–0.3% as reported by Ikeuchi [22]. The reported incidence of DLM is higher in Asian countries, especially in Japan and Korea, than in Western countries,

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with an incidence of 16.6% of arthroscopic procedures for Japanese patients [22] and 15.3% for Korean patients [39].

A discoid meniscus is characterised by relatively insufficient vascularisation, weak attachment to the posterior capsule, and greater thickness than a normal meniscus [21]. Various symptoms may be caused by the abnormal mechanical load between the lateral femoral condyle and the Tibial plateau, disorganised collagen fibres, and poor blood supply compared with a normal meniscus [5, 7, 9].

Asymptomatic DLM does not require treatment; however, operative treatment is necessary when symptoms such as pain, locking, and/or limited range of motion are severe or when conservative management fails. Symptomatic DLM has been found mainly in children or adolescents [2–4, 10, 12, 15, 17, 18, 20, 21, 24, 25, 27, 28, 32, 34, 36, 37, 41, 42, 44–46], although clinicians sometimes encounter adult patients with osteoarthritic changes who had no symptoms until middle age [1, 19, 29, 30, 35, 48]. Bin et al. [6] first reported a relationship between DLM types and tear patterns. The authors indicated that their method of classification was simple and useful for planning treatment. However, a few large-sample studies have correlated the types and tear patterns of symptomatic DLM [6, 8]. Additionally, no previous reports have clarified the characteristics of clinical symptom onset or tear patterns by age group. Clarifying the characteristics of symptom onset, especially in children and adolescents, would be helpful for diagnosing DLM in daily clinical practice.

The purpose of this study was to review the relationship between DLM types and tear patterns, the relationship between tear patterns and the age distribution, and the causes of age-specific clinical symptom onset in patients with symptomatic DLM during the past 20 years in our institution. The hypothesis of this study was that a relationship exists between DLM types and tear patterns, between tear patterns and the age distribution, and between causes of clinical symptom onset and the age distribution.

Materials and methods

This study was approved by the review board of our institution (No. O-0773). The procedures were in accordance with the ethical standards of the responsible committees on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013. Information regarding the protocol of this study was disclosed at our Faculty of Medicine, and research subjects were given an opportunity to refuse inclusion in this study. Patients who did not wish to take part were not enrolled in this study. No participants refused inclusion in the study.

The therapeutic strategy for DLM at our institution is as follows: non-operative treatment for isolated asymptomatic

DLM and operative treatment for patients with symptoms disturbing daily life or sports activities or with failure of conservative management. Arthroscopic surgeries were performed in 1650 knees at our institution from January 2000 to December 2019, and DLM was identified in 162 of these 1650 knees; 307 ipsilateral knees underwent repeat arthroscopic surgeries during the same period, including seven knees with DLM. The inclusion criteria were symptomatic DLM (swelling, pain, snapping, clicking, catching, locking, and limited range of motion) and primary surgery for DLM. The exclusion criteria were asymptomatic DLM with other concurrent knee disorders discovered incidentally as well as concomitant ligamentous injuries or previous surgery for DLM in the ipsilateral knee. Finally, the data for 138 knees in 105 patients were reviewed (Fig. 1). Patients who underwent non-operative treatment were excluded from this study to allow for classification of the DLM types and tear patterns by arthroscopic findings.

Classification

Five senior orthopaedic surgeons performed the arthroscopic surgeries and documented the types of DLM as complete, incomplete, or Wrisberg type according to Watanabe's classification [43] in the operative reports. According to the operative reports and intraoperative imaging data (images and/or videos), a single orthopaedic surgeon classified the DLM tears into six categories according to the modified Bin's classification [6], which is based on O'Connor's classification of meniscal tears [40], as follows: simple horizontal tear; complicated horizontal tear comprising a horizontal

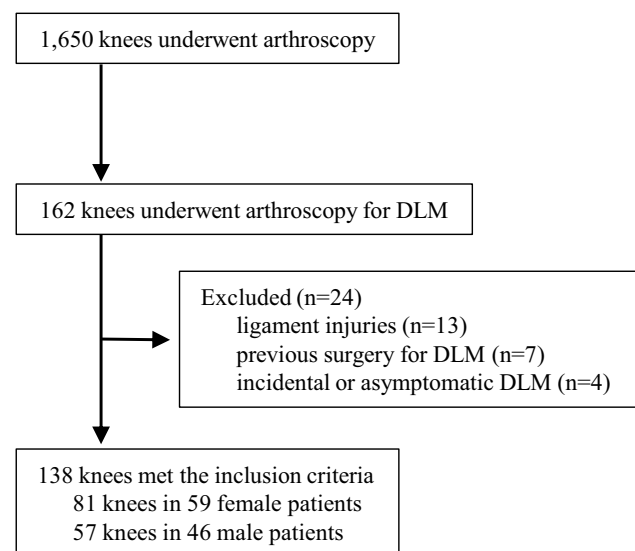


Fig. 1 Flowchart of participant enrolment. Of 1650 arthroscopic surgeries over a 20-year period, 162 were performed for DLM and 138 were evaluated in this study. *DLM* discoid lateral meniscus

and vertical tear; longitudinal tear, including peripheral and bucket-handle tear; radial tear, including oblique tear; complex tear comprising two major tears excluding a horizontal tear or more than three major tears, including a horizontal tear; and no tear. The “no tear” pattern was defined as DLM with only simple degeneration, such as fraying on the surface or no obvious damage. For Watanabe’s and Bin’s classifications, the kappa coefficient of the intra-rater reliability was 0.88.

Patients were divided into five groups according to their age: < 10, 10–19, 20–39, 40–59, and ≥ 60 years. The age at clinical symptom onset was defined by the age at surgery. In addition, patients were classified according to the following causes of clinical symptom onset: sports activities, minor trauma in daily living (e.g., falling, twisting the knee while walking, or becoming injured while rising/standing up), and no traumatic episode.

Statistical analysis

Demographic characteristics are summarised by standard descriptors (e.g., averages and standard deviations for continuous variables such as age and percentages for categorical variables). Fisher’s exact test was used to analyse the relationship between the DLM types and tear patterns and the causes of clinical symptom onset. In addition, the relationship between the age distribution and causes of clinical symptom onset and the tear patterns were analysed by the same method. Because the sample sizes of the categories were small, Fisher’s exact test was used for the analysis of qualitative indices. Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS) version 21.0 (IBM Corp., Armonk, NY, USA). A p value of < 0.05 was considered statistically significant.

Based on a power of 0.8, α of 0.05, and effect size of 0.3, the sample size was calculated to be 143 as analysed by G*Power version 3 [13].

Results

This study included 138 knees in 105 patients (81 knees in 59 female patients and 57 knees in 46 male patients). The mean age at surgery was 21.5 ± 15.8 years (range 5–76 years). The complete type of DLM was found in 78 (56.5%) knees, followed by the incomplete type of DLM in 60 (43.5%) knees; no knees had the Wrisberg type. The overall tear patterns were as follows: 30 simple horizontal, 48 complicated horizontal, 20 longitudinal, 9 radial, 2 complex, and 29 no tear. Complicated horizontal tear was the most common tear pattern with complete DLM (33 of 78, 42.3%), while no tear was the most common pattern with incomplete DLM (20 of 60, 33.3%). Simple horizontal and

complicated horizontal tears were found significantly more frequently with complete DLM; conversely, radial tears and no tear were found significantly more frequently with incomplete DLM ($p < 0.0001$) (Table 1). Overall symptoms, main complaints of each knee, according to tear patterns are shown in Table 2. The predominant symptom was pain (81.9%); in addition, limited range of motion and catching/locking were found in the complete type of DLM. There was no significant difference in the distribution of DLM types and causes of symptom onset (n.s.) (Table 3).

Classifying all patients by age group, 74 (53.6%) knees with DLM were found in teenagers. Sports activities caused clinical symptom onset significantly more often in teenaged patients compared with no traumatic episode in patients under 10 years and minor trauma in daily living in those aged 40–59 years and ≥ 60 years ($p < 0.0001$) (Fig. 2). The age distribution and tear patterns are shown in Table 4. No relationship was found between the two groups (n.s.). No tear was common in teenaged patients, and complicated horizontal tears were common in patients over 20 years of age (Table 4).

Discussion

The most important findings of the present study were a significant difference in the distribution between DLM types and tear patterns and the causes of clinical symptom onset and age groups. Additionally, specific characteristics of tear patterns were found according to age group.

Watanabe classified DLM into three types: complete, incomplete, and Wrisberg type [43]. This classification was commonly applied in previous reports of DLM. However, no patients in our study had Wrisberg type DLM, which has a reported incidence of approximately 0.2% [31]. Regarding

Table 1 Relationship between DLM types and tear patterns

Tear pattern	Type		Total
	Complete	Incomplete	
Simple horizontal tear	23 (16.7)*	7 (5.1)	30 (21.7)
Complicated horizontal tear	33 (23.9)*	15 (10.9)	48 (34.8)
Longitudinal tear	12 (8.7)	8 (5.8)	20 (14.5)
Radial tear	1 (0.7)	8 (5.8)*	9 (6.5)
Complex tear	–	2 (1.4)	2 (1.4)
No tear	9 (6.5)	20 (14.5)*	29 (21.0)
Total	78 (56.5)	60 (43.5)	138

Values are presented as n (%)

Fisher’s exact test was used to statistically analyse the association between DLM types and tear patterns

DLM discoid lateral meniscus

* $p < 0.0001$

Table 2 Symptoms of DLM according to tear patterns

Tear pattern	Type	Symptom				
		Pain	Limited range of motion	Snapping/ click	Catching/ locking	Others
Simple horizontal tear	Complete	20	2	1	–	–
	Incomplete	7	–	–	–	–
Complicated horizontal tear	Complete	27	–	1	3	2
	Incomplete	15	–	–	–	–
Longitudinal tear	Complete	10	1	1	–	–
	Incomplete	5	–	1	–	2
Radial tear	Complete	1	–	–	–	–
	Incomplete	7	–	1	–	–
Complex tear	Complete	–	–	–	–	–
	Incomplete	2	–	–	–	–
No tear	Complete	5	4	–	–	–
	Incomplete	14	–	6	–	–

Values are presented as *n*
DLM discoid lateral meniscus

Table 3 Distribution of DLM types and causes of clinical symptom onset

Cause of symptom onset	Type		Total
	Complete	Incomplete	
Sports activities	40 (29.0)	40 (29.0)	80 (58.0)
Minor trauma in daily living	7 (5.1)	6 (4.3)	13 (9.4)
No traumatic episode	31 (22.5)	14 (10.1)	45 (32.6)

Values are presented as *n* (%)

DLM discoid lateral meniscus

Fisher’s exact test was used to statistically analyse the association between DLM types and causes of symptom onset (n.s.)

the relationship between DLM types and tear patterns, Bin et al. [6] reported that simple horizontal and complicated horizontal tears were found significantly more often in complete DLM, whereas radial, degenerative, and complex tears were found significantly more often in incomplete DLM. Chen et al. [8] reported that horizontal and longitudinal tears were the most common tear patterns in complete DLM and that longitudinal and radial tears were most common in incomplete DLM. In our study, simple horizontal and complicated horizontal tears were found significantly more often with complete DLM, and radial tears and no tears were found significantly more often with incomplete DLM. As a result, horizontal tears tended to occur with complete DLM and vertical tears tended to occur with incomplete DLM. Bin et al. [6] stated that clarifying the association between DLM types and tear patterns would be useful to predict tear patterns preoperatively, which would also help surgeons who encounter difficulty inspecting detailed tear patterns in very narrow spaces, especially with complete DLM.

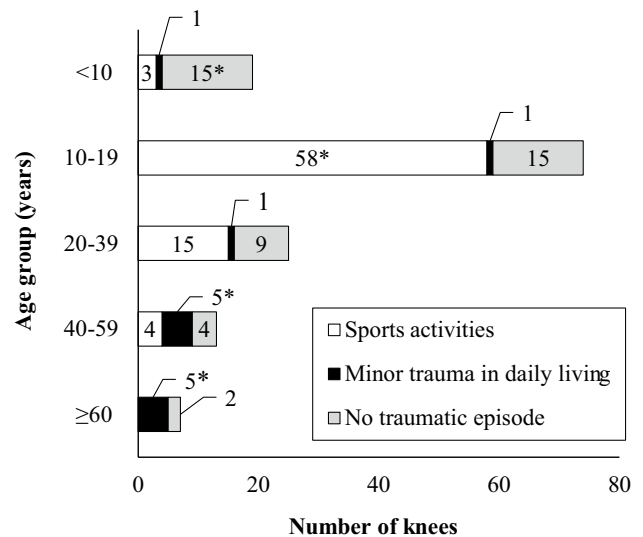


Fig. 2 Age distribution and causes of clinical symptom onset. Fisher’s exact test was used to statistically analyse the distribution of clinical symptom onset by age group (*significantly more frequent: $p < 0.0001$). Sports activities caused clinical symptom onset significantly more often in teenaged patients compared with no traumatic episode in patients under 10 years and minor trauma in daily living in those aged 40–59 years and over 60 years

DLM has a higher risk of meniscal injury than does a normal meniscus [38]. Some previous reports of DLM revealed a decrease in the number of collagen fibres and discontinuity and inhomogeneity of the collagen network compared with a normal meniscus [5, 33]. In our study, 58 (42.0%) patients were referred for symptomatic DLM caused by minor trauma or no traumatic episode, indicating that DLMs have a higher risk of meniscal injury. Additionally,

Table 4 Age distribution and tear patterns

Tear pattern	Age group (years)				
	< 10	10–19	20–39	40–59	≥ 60
Simple horizontal tear	5	16	6	1	2
Complicated horizontal tear	5	18	12	10	3
Longitudinal tear	4	12	2	1	1
Radial tear	–	5	3	1	–
Complex tear	–	2	–	–	–
No tear	5	21	2	–	1
Total	19	74	25	13	7

Values are presented as *n*

Fisher's exact test was used to statistically analyse the association between the age distribution and tear patterns (n.s.)

previous studies demonstrated that histological and biological differences between the complete and incomplete types of DLM [23]. The presence of histological, biologic, and morphologic variants may result in differences in the types and tear patterns between complete and incomplete DLM.

In the present study, 66.7% of DLMs exhibiting clinical symptom onset with no traumatic episode were found in patients under 10 years of age and in teenagers. This indicates that a morphologic variant of DLM (such as overload distribution or thick shock absorption) and a histological variant of DLM compared with a normal meniscus may result in meniscal tears and symptoms even with no traumatic episode in children. Among teenagers, 58 of 74 (78.4%) knees were referred for symptomatic DLM caused by sports activities, which was a significantly higher frequency than in the other age groups. The increased exercise level during sports activities resulting in increased physical stress in teens may cause horizontal tears and clinically manifest as symptomatic knees with no tears. Moreover, vertical tears may be caused by minor sports injury owing to histological and biological variants compared with a normal meniscus. Clinical symptom onset caused by minor trauma in daily living was more frequent in patients aged 40–59 years and those over 60 years. Regarding the tear pattern tendencies in both age groups, 16 of 20 (80%) knees had horizontal tears that might have been due to long-term overload according to morphological and histological variants, which may cause symptoms after only minor trauma. To our knowledge, this is the first report investigating the causes of clinical symptom onset of DLM by age group. Clarifying the causes and characteristics of symptoms by age group may help clinicians to diagnose or suspect symptomatic DLM.

26 (89.7%) DLMs with no tear were found in patients under 10 years of age and in teenagers, indicating that DLMs with no tear are very rare in middle age. The absence of a tear was significantly more common in incomplete DLM, which suggests that complete DLMs are more easily injured

than incomplete DLMs. In our study, the symptom of the limited range of knee motion was common with the complete type of DLM. Conversely, snapping or clicking was common with the incomplete type. Yoo et al. [45] reported that knee extension block occurred exclusively in complete DLM (vs. incomplete DLM) and was significantly correlated with meniscal instability in the posterior segment. Furthermore, Klingele et al. [26] reported that the prevalence of peripheral rim instability was significantly more common with complete DLM and in younger patients. Therefore, symptoms of DLM, such as pain; limited range of motion, especially extension limitation; and snapping or clicking may appear even with no obvious tear, especially in young patients.

The incidence of DLM in the Japanese population was reported as 16.6% by Ikeuchi [22] and 13% by Fukuta et al. [14]. In the present study, 162 DLMs were found in 1,650 knees during arthroscopic procedures among 307 knees that underwent previous surgeries during the same period, including 7 knees surgically treated for DLM. Therefore, the incidence of DLM was 11.5% (155/1343 knees). Most previous reports evaluated specific age groups or involved a different study design than in our study, such as clinical studies and cadaveric studies. In the present study, the incidence of DLM was calculated only in specific participants who underwent arthroscopic knee procedures, which may not indicate the accurate incidence of DLM in the Japanese population.

This study has several limitations. First, this was a retrospective study at a single centre; therefore, the results cannot be generalised to the whole Japanese population or to patients in other countries. Second, the sample we evaluated may not be representative of all discoid menisci, or even all symptomatic menisci, because only operatively treated DLMs were included. However, our institution is a referral hospital, and most patients had already received conservative treatment at their hospital of origin. Third, there was bias in the distribution of the age groups. However, the sample size in this study was > 100 patients, and approximately 70% were children and adolescents, which is one feature of symptomatic DLM. Fourth, the duration between the time of surgery and symptom onset was not investigated, and the age at symptomatic onset was defined as the age at which patients underwent surgery; this may have affected the accuracy of the age distributions. Fifth, although the tear patterns were classified by a single orthopaedic surgeon according to the arthroscopic imaging data and surgical records documented by experienced orthopaedic surgeons, the tear pattern descriptions, especially for complex tears, might have resulted in bias. Finally, the surgical management of DLM was not reviewed in this study. The surgical management for DLM changed during the 20-year period of this study. Total meniscectomy or subtotal meniscectomy

was a major surgical treatment for DLM in the early study period. Because of the previously reported short-, mid-, and long-term prognosis following partial central meniscectomy with repair [2, 3, 32, 46], total meniscectomy or subtotal meniscectomy for DLM was rarely performed late in the study period. Therefore, reviewing the surgical management in this study might reveal bias.

DLM is sometimes difficult to diagnose at the first visit in daily clinical practice; however, it is relatively easy to diagnose if MRI is performed with suspicion. Our findings regarding age-specific causes of clinical symptom onset may help clinicians to suspect the presence of DLM and plan MRI examinations for accurate diagnosis. Additionally, differences in DLM tear patterns between MRI and arthroscopic findings are sometimes encountered during surgery. Prediction of tear patterns before surgery is useful for surgical management, especially meniscal repair.

Conclusions

With respect to the relationship between the DLM types and tear patterns, the present study showed that simple horizontal and complicated horizontal tears were significantly more common in complete DLM, whereas radial tears and no tears were significantly more common in incomplete DLM. These findings and tear pattern tendencies by age group could be useful to predict the tear pattern before surgery. Causes of clinical symptom onset in DLM were characteristic according to the age group, which might help clinicians to suspect the presence of DLM in daily clinical practice.

Author contributions NY wrote, reviewed, and revised the manuscript. NY, TT, YM, and TY performed the surgery, collected clinical data, and were responsible for postoperative follow-up. All authors have reviewed and approved the manuscript.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was approved by the review board of Faculty of Medicine, University of Miyazaki (No. O-0773). Information regarding the study protocol was disclosed prior to the study.

Informed consent Information regarding the protocol of this study was disclosed at HP of the Faculty of Medicine, University of Miyazaki, and research subjects were provided an opportunity to refuse inclusion in this study. Patients who did not want to take part were not enrolled in this study.

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