Effect of discoid lateral meniscus on tibiofemoral joint cartilage damage in middle-aged patients

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Research Article

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Abstract

Purpose: To investigate the effect of discoid lateral meniscus (DLM) on cartilage damage of the medial and lateral compartments of the knee in middle-aged patients.

Methods: We analyzed data from 44 patients (54 knees) with symptomatic discoid lateral meniscus (DLM group) and 30 patients (30 knees) with a non-discoid lateral meniscus tear (control group). All patients were over 40 years old. We compared the tibiofemoral angle (TFA) and cartilage injury rate between the two groups. We further classified DLM group patients based on dysmorphic features of the menisci (DLM type), presence/absence of meniscal tear, and symptom durations, then analyzed whether these parameters could affect the number of cartilage injuries in the knee medial and lateral compartments.

Results: DLM group showed higher TFA values ($2.18^{\circ} \pm 2.86^{\circ}$) than control group ($0.84^{\circ} \pm 1.35^{\circ}$, $P=0.002$), and a higher occurrence of medial compartment cartilage damage ($P=0.003$). Within the DLM group, patients with cartilage damage showed higher BMI than those without cartilage damage ($P=0.009$ for medial compartment and $P=0.001$ for lateral, respectively). We found that having symptoms for more than 6 months was associated with cartilage damage in the lateral compartment ($P=0.021$), but not the medial compartment ($P=0.858$). Neither presence/absence of a meniscal tear, nor DLM type affected cartilage injury rate in either the medial or lateral compartment ($P>0.05$).

Conclusion: Varus inclination caused by DLM could lead to cartilage injury in the medial compartment in middle-aged patients, but may not reduce the occurrence of chondral damage in the lateral compartment. Rather, lateral compartment chondral damage in patients with DLM was mainly related to symptom duration.

Introduction

Discoid lateral meniscus (DLM) is an anatomical abnormality, which has higher incidence in East Asia (15.3%-16.6%) [2, 5]. Compared to a normal lateral meniscus, a DLM is more likely to be damaged owing to its decreased collagen fibers and abnormal collagen orientation [4, 22], and the increased thickness and abnormal vascularity of the discoid meniscus makes it prone to tearing [7].

Articular cartilage damage of the lateral compartment is a common secondary injury of DLM [9, 12, 17, 25]. In the study of 38 patients with Osteochondritis Dissecans of the lateral femoral condyle conducted by Deie et al.[9], 34 patients were found to have DLM. Mitsuoka et al.[25] also reported that DLM can cause Osteochondritis Dissecans of the lateral femoral condyle. They suggested that cartilage damage will be caused by abnormal load even when there is no tear of the DLM. However, previous studies mainly focused only on the lateral compartment.

DLM is generally thicker than normal meniscus, and due to the bulk of tissue between the articular surfaces, it might affect the axial alignment of the lower limb. Nawata et al. [27] found that, in patients

with DLM who were more than forty years old, varus inclination was observed more frequently than valgus inclination. Subchondral bone sclerosis was more common in the medial compartment. Kim et al. [20] also found that middle-aged (over forty) patients with DLM had a higher prevalence of varus alignment. Usually, varus alignment increases medial tibiofemoral load [10]. Sharma et al.[30] reported that varus alignment was associated with a greater risk of medial osteoarthritis progression and a reduced risk of lateral progression. However, few studies have discussed the relationship between discoid meniscus and medial compartment osteoarthritis.

Therefore, the purpose of the current study was to evaluate arthroscopic and radiographic characteristics of DLM in patients over forty years old. We aimed to investigate whether DLM could lead to varus alignment of the knee, and whether that could then result in medial compartment cartilage injury. We hypothesized that DLM could lead to varus alignment, which can increase the risk of medial compartment cartilage injury but may simultaneously protect the lateral compartment articular cartilage.

Materials And Methods

This retrospective study was approved by the Medical Ethics Committee of our Institution. All patients were recruited after providing informed consent for analysis of their clinical data.

Patient Selection

A retrospective chart review was conducted in a single institution for middle-aged patients (over forty) diagnosed with symptomatic DLM from August 2017 to July 2018. All the patients were confirmed to have DLM via arthroscopic examination. The following exclusion criteria were used: (1) under the age of forty or symptoms started before forty, (2) musculoskeletal deformities of the lower extremities or knee ligament injuries (detected through MRI and/or physical examination), (3) previous surgical history of the lower limbs. After applying these criteria, 54 knees (44 patients) were included in the DLM group. For comparative analysis, control subjects were selected from our institution from the same time period. Patients in the control group were confirmed via arthroscopy to have a lateral meniscus tear, and were also confirmed to have a non-discoid meniscus type. The same exclusion criteria used for the DLM group were applied to the control group. Ultimately, 30 knees (30 patients) were included in the control group. Demographic variables, including age, sex, body mass index (BMI), injury side and symptom duration, were obtained from patient medical records. The duration of symptoms was defined as the period from the onset of symptoms to the time of surgery; this was divided into ≤ 6 months and > 6 months.

Radiographic analyses

Standing anteroposterior radiographs were obtained one to three days preoperatively with the patient standing on level ground with both knees straight and the patellae pointed forward. Tibiofemoral angle (TFA) was used to evaluate the axial alignment of the lower limb. The TFA was determined by drawing a line from the center of the femoral head to the knee joint center and another line from the knee joint center to the ankle joint center, and then calculating the angle between these two lines (Fig 1). The center

of the femoral head, knee joint and ankle joint were determined according to previously established methods[26, 34]. We used Picture Archiving and Communication System (PACS) to construct a rectangle within the femoral head, with three of the four points located on the articular surface of the femoral head and the fourth point automatically drawn by the computer, so that two diagonals could be determined as well as the location of the femoral head center [34]. The center of the knee was defined as the midpoint between the tips of the tibial spines[26]. The center of ankle was considered to be the center of the talus at the level of the subchondral bone of the talus[26]. The accuracy of TFA was within 0.1°. Radiographic data were measured using Syngo Studio VB36C PACS (Siemens, Germany). All radiographs were measured independently by two surgeons and the mean of the two values was taken for further calculations.

Arthroscopic assessment and treatment

All procedures were performed at one institution by a single surgeon. Patients with DLM were treated by trimming the meniscus into a semilunar shape, and patients with non-discoid lateral meniscus were treated with partial meniscectomy. The Watanabe classification system was used to determine the type of DLM [35]. The presence or absence of a meniscal tear was recorded. The status of the articular cartilage in both the lateral and medial compartments was evaluated on the basis of the Outerbridge grading system [28]. An Outerbridge classification grade ≥ 3 was recognized as cartilage damage.

Statistical analysis

Data analysis was performed using the SPSS for Windows v.21.0 statistical software (SPSS Inc., Chicago, IL, USA). Quantitative data was presented as mean and standard deviation and normal distribution was tested using the Shapiro-Wilk test. The Student's t-test was then used for the comparison of normally distributed quantitative variables while the Mann-Whitney U test was used for non-normally distributed data. In addition, the Chi-square and Fisher exact tests were applied to compare frequencies across sex, injured side, symptom duration and rate of chondral damage between the DLM and control groups. All statistical analyses were performed at a significance level of $P=0.05$.

Results

The results revealed that there were no statistical differences between the two groups in sex, age, BMI, involved side and symptom durations (Table 1). Preoperative standing radiographs showed that varus deformity was more frequent in DLM group than in control group. Compared to control group, DLM group showed higher TFA (DLM: $2.18^{\circ} \pm 2.86^{\circ}$; control: $0.84^{\circ} \pm 1.35^{\circ}$, $P=0.002$), and higher incidence of medial compartment cartilage damage ($P=0.003$). Lastly, no significant difference was observed in the incidence of lateral compartment chondral damage between the two groups (Table 2).

Among the 54 knees in DLM group, 17 knees had only medial compartment chondral damages, 10 knees had only lateral compartment chondral damages, and 5 knees had both medial and lateral compartment chondral damages (Table 2). Those with medial compartment chondral damage had higher TFA and

higher BMI than those without ($P=0.009$ and $P=0.037$, respectively, Table 3). However, there was no significant difference between those with lateral compartment cartilage damage and those without in terms of age or TFA (Table 4). Those who experienced symptom duration longer than 6 months were more likely to have lateral compartment chondral damage ($P=0.022$ Table 5). Neither the presence or absence of a meniscal tear nor lateral meniscus types significantly influenced chondral damage in either the lateral or medial compartment (Fig 2).

Discussion

This study found that varus inclination caused by DLM could lead to higher risk of cartilage injury in the medial compartment in patients over 40 years old. However, this same varus inclination may not reduce the occurrence of chondral damage in the lateral compartment. Rather, lateral compartment chondral damage in patients with DLM was mainly related to symptom duration.

Previously, Habata et al. [18] reported normal axial alignment of the lower limb in patients with DLM. However, Kim et al. [20] reported that patients with DLM who did not have a symptomatic tear until they were middle-aged showed a higher prevalence of varus knee in middle age. They claimed that the patients in Habata et al.'s [18] study might have been too young (average age, 22.3 years) for the discoid meniscus to lead to malalignment of the lower limb [20]. Nawata et al. [27] also found that, in patients who were more than forty years old with DLM, varus inclination was observed more frequently than valgus inclination. Subchondral bone sclerosis was more common in the medial compartment. Milewski et al. found that increased lateral joint space width on weightbearing radiograph was associated with DLM [24]. We assume widened lateral joint space might be responsible for developing varus inclination (Fig 3). Varus deformity could increase medial tibiofemoral load and lead to chondral damage [10]. Sharma et al. [30] reported that varus alignment was associated with a greater risk of medial osteoarthritis progression. Therefore, one possible reason for chondral damage in the medial compartment of middle-aged patients with DLM is that varus inclination caused by DLM leads to increased loading on the medial compartment. Although many authors consider treatment unnecessary for asymptomatic patients because the knee may have adapted to the anatomy of the discoid meniscus [1, 3, 22, 31], DLM may take several years or decades to lead to malalignment or degenerative changes in the knee. Surgeons should pay more attention to the axial alignment of the lower limb when dealing with asymptomatic DLM patients.

Sharma et al. [30] reported that varus alignment was associated with a reduced risk of lateral osteoarthritis progression due to the lack of load on the lateral compartment in the varus knee. However, our results showed that there were still 10 knees (15 knees in total) of lateral compartment cartilage damage in the DLM group. Ding et al. [12] reported that long symptomatic duration (>6 months) was more frequently related to articular cartilage lesions of the lateral compartment regardless of age, similar to the findings of our current study. Speaking of symptoms, adult patients may present with pain and mechanical symptoms (knee catching or locking) [11] because of abnormal load transmission and dislocated tear fragment. Both of these factors could increase the risk of cartilage damage over time.

Besides, the mean difference of TFA between the two groups was only 1.4°. Thus, a slight varus change may not offset the impact of symptomatic duration.

Body mass index (BMI) plays an important role in knee osteoarthritis. Higher BMI indicates excessive weight, which would increase joint loading, resulting in deleterious effects on weight-bearing joints. The additional mass can increase stress on the articular cartilage to exceed beyond biological capabilities, and therefore causing degenerative changes [32, 33]. The patients who had higher BMI were more likely to have chondral damages regardless of a lateral or medial compartment in our study. Some studies reported that the progression of knee osteoarthritis could be slowed down by BMI reduction [15, 16]. Liukkonen et al. [23] suggested that bariatric surgery-induced weight loss changed knee kinetics and kinematics and can slow-down cartilage degeneration. Non-operative weight loss of at least 5.1%, including through dietary intervention, also yields symptomatic improvement [21]. Therefore, we suggested that patients with DLM should be advised to manage their BMI within a normal range.

Watanabe et al. [35] first classified the DLM as complete, incomplete, and whisberg type. There were no significant differences between complete and incomplete DLM in terms of medial compartment cartilage damages in our study. The complete DLM has larger width than incomplete DLM. Choi et al. [6] reported that the average width of complete and incomplete DLM observed by MRI was 23.3 mm and 19.3 mm, respectively. Yet, there were few studies compared the thickness between complete and incomplete DLM. Kim et al. [21] found no statistical differences between complete and incomplete groups according to lateral joint space height. Consequently, a complete and incomplete type of DLM may produce a similar effect on the axial alignment of the lower limb, resulting in similar cartilage injury rates in the medial compartment. Kim et al. [19] found no significant differences in chondral lesions between complete and incomplete DLM. Ding et al. [12] also reported that no statistical significance in the relation between the different types of DLM and articular cartilage lesions, corroborating with the results from the present study.

Moreover, this study found no relationship between the tear of DLM and articular cartilage lesions, similar to previously reported results [12]. Whether meniscal tear is the cause or result of osteoarthritis is still unclear [13]. The menisci and articular cartilage have many similar components and properties and are subjected to similar stresses. Thus, the pathologic processes resulted from osteoarthritis could damage joint cartilage and affect the integrity of the menisci [13]. The meniscus has an essential role in shock absorption and load transmission. The meniscus tears cause abnormal distribution of load transmission, leading to articular cartilage damage[14]. A decreased number of collagen fibers and the disorganization of the circular collagen network are observed in DLM [4, 8, 29]. The inner circumferential collagen fiber network represents the main portion of the meniscus tissue and dissipates the hoop stresses on the meniscus structure during weight bearing[29]. Therefore, due to morphological and ultrastructural abnormalities, DLM might lead to abnormal load transmission without a tear, eventually resulting in articular cartilage damage in lateral compartment. As to medial compartment, with or without a tear may have same effect on axial alignment of the lower limb. Habata et al.[18] reported that axial

alignment of the lower limb did not relate with the occurrence of the DLM tears. Further study is needed to investigate the reason.

This study had some limitations that are inherent to a retrospective review. First, some of the data, such as the symptomatic duration was self-reported, and this might have introduced some errors. Second, we could not determine whether the patients the onset timing of our patients' varus knee. We could not determine whether the varus knee was congenital or a secondary result of DLM. Third, the small number of patients might have introduced a bias in the results. Therefore, further multi-centers prospective studies are needed to validate these findings.

Conclusion

The varus inclination caused by DLM could lead to cartilage injury in the medial compartment in patients over 40 years old. The patients who had larger varus angle were more likely to have cartilage damage in medial compartment. Furthermore, lateral compartment chondral damage in patients with DLM was mainly related to long symptom duration (> 6months). Moreover, varus inclination caused by DLM may not reduce the occurrence of chondral damage in the lateral compartment. Nonetheless, the absence or presence of tear or discoid dysmorphic types are not related to chondral damages.

List Of Abbreviations

DLM: discoid lateral meniscus

TFA: tibiofemoral angle

MRI: magnetic resonance imaging

BMI: body mass index

PACS: picture archiving and communication system

Declarations

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

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Table

Table1.Comparison of demographic characteristics between DLM Group and Control Group

	DLM (n=54)	Control(n=30)	P value
Age,y,mean SD	48.5±5.1	49.0±5.5	.654
Male Sex	7(13%)	9(30%)	.057
Injury side,right	29(53.7%)	14(46.7%)	.536
Symptom duratiuon, >6 months	28(51.9%)	15(50%)	.871
BMI,kg/m ² ,mean SD	24.0±3.1	23.0±2.5	.182

Data are presented as mean standard deviation or number of knees.

Table 2. Comparison of TFA and chondral damage between DLM Group and Control Group

	DLM	Control	P value
number of knees	54	30	
TFA, °, mean SD	2.2±2.9	0.8±1.4	.005
medial compartment damage	22(40.7%)	3(10%)	.003
isolated medial compartment damage	17(31.5%)	2(6.7%)	.009
isolated lateral compartment damage	15(27.8%)	7(23.3%)	.657
combined lateral compartment damage	10(18.5%)	6(20%)	.868
two compartment damage	5(9.3%)	1(3.3%)	.414

Data are presented as mean standard deviation or number of knees (percentage). Bold indicates P < 0.05.

Table 3. Comparison of demographic characteristics according to the medial compartment chondral damage

	Chondral damage	Without chondral damage	P value
Number of knees	22	32	
Age, y, mean SD	48.9±4.6	48.2±5.5	.599
Male Sex	4(18.1%)	3(9.3%)	.425
BMI, kg/m ² , mean SD	25.2±2.9	23.2±3.0	.009
TFA, °, mean SD	3.1±2.8	1.4±2.8	.037

Data are presented as mean standard deviation or number of knees. Bold indicates P < 0.05.

Table 4. Comparison of demographic characteristics according to the lateral compartment chondral damage

	Chondral damage	Without chondral damage	P value
Number of knees	15	39	
Age, y, mean SD	50.0±6.2	47.9±4.6	.237
Male Sex	2(13.3%)	5(12.8%)	.996
BMI, kg/m ² , mean SD	26.2±3.3	23.2±2.6	.001
TFA, °, mean SD	2.7±3.3	2.2±2.6	.509

Data are presented as mean standard deviation or number of knees. Bold indicates P < 0.05.

Table 5. Comparison of chondral damage based on different symptoms duration

	≤ 6 months	> 6 months	P value
Total number of knees	28	26	
Total medial compartment damage	8(28.6%)	14(53.8%)	.059
Isolated medial compartment damage	6(21.4%)	11(42.3%)	.099
Total lateral compartment damage	4(14.3%)	11(42.3%)	.022
Isolated lateral compartment damage	2(7.1%)	8(30.8%)	.037
Both two compartment damage	2(7.1%)	3(11.5%)	.663

Data are presented as as mean standard deviation or number of knees(percentage).Bold indicates P < 0.05.

Figures

Figure 1

A: The tibiofemoral angle (TFA) is the angle formed by mechanical axis of tibia (the distance from the center of the knee joint to the center of the ankle joint) and mechanical axis of femur (the distance from the center of the femoral head to the center of the knee joint). Construct a rectangle within the femoral head, with three of the four points located on the articular surface of the femoral head and the fourth point automatically drawn by the computer, so that two diagonals could be determined as well as the

location of the femoral head center B: The center of the knee was defined as the midpoint between the tips of the tibial spines. C: The center of ankle was considered to be the center of the talus at the level of the subchondral bone of the talus.

Figure 2

A and B: The differences of chondral damage in lateral or medial compartment based on presence/absence of a meniscal tear. C and D: The differences of chondral damage in lateral or medial compartment based on DLM types.

Figure 3

A and B: Widened lateral joint space caused by DLM may result in increased TFA.