Influential factors of postoperative outcomes of symptomatic lateral discoid meniscus

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Abstract

**Background:** Discoid lateral meniscus (DLM) have a higher rate of tear and degeneration for its abnormal shape and structure. Arthroscopy is the main treatment for symptomatic DLM, however, postoperative clinical outcomes vary widely resulting from effects of diverse factors. Therefore, the present research aims to explore the factors influencing postoperative clinical outcomes of symptomatic DLM.

**Methods:** Patients with discoid meniscus who underwent arthroscopic surgery at our hospital from 9/2008 to 9/2015 were selected according to the inclusion and exclusion criteria. Gender, body mass index (BMI), and 18 other factors were selected as potential predictors that might affect postoperative outcomes. Knee function was assessed by the Lysholm, Tegner, International Knee Documentation Committee (IKDC) and Ikeuchi scales. Univariate analyses (rank-sum test and chi-squared test) and multivariate analyses (ordered logistic regression and logistic regression) were used to detect the risk factors bearing on postoperative outcomes. P<0.05 was considered statistically significant.

**Results:** A total of 502 patients were enrolled. Female gender was an influencing factor for Lysholm (P=0.002, odds ratio (OR)=2.713), Tegner (P=0.001, OR=2.526), IKDC (P=0.022, OR=1.735) and Ikeuchi scores (P=0.010, OR=2.164). BMI was negatively correlated with Lysholm (P=0.007, OR=1.119) and IKDC (P=0.029, OR=1.088) scores. Work intensity was negatively related to IKDC (P=0.038, OR=1.492) and Ikeuchi (P=0.014, OR=1.689) scores. Age of onset was inversely correlated with Tegner (P<0.001, OR=1.109) score. Symptoms duration and IKDC (P=0.002, OR=1.020) had an inverse correlation. Lack of cartilage lesions was a protective factor in terms of Tegner score (P<0.001, OR=0.261). Outerbridge grade was negatively correlated with Lysholm (P=0.016, OR=1.589) and Ikeuchi (P=0.017, OR=1.582) scores. Saucerization with repair was a risk factor for poor Ikeuchi scores (P=0.037, OR=4.328) in terms of subtotal/total meniscectomy.

**Conclusion:** Arthroscopic treatment of symptomatic DLM is safe and effective. Female sex, cartilage lesions and saucerization with repair may be related to unfavourable postoperative outcomes. Clinical efficacy may worsen with increasing BMI, work intensity, symptomatic duration, age of onset and Outerbridge grade.
Background
A discoid meniscus has an abnormal shape and structure. The disintegration of the circular collagen fibre system in the discoid meniscus matrix may be responsible for the fact that discoid meniscuses have a higher tear rate and higher degeneration variability than normal meniscuses [34, 36]. Clinically, discoid lateral meniscus (DLM) is common, with a high prevalence in Asian populations (10.9%-16.6%) [18]; bilateral DLM accounts for 79%-97% of all cases [30]. Symptomatic discoid meniscus is characterized by pain, swelling, snapping, locking, knee instability and limited mobility [13, 25]; this anomaly is mainly diagnosed by magnetic resonance imaging (MRI) and arthroscopy and is chiefly treated by arthroscopic surgery [28]. Although the overall postoperative clinical outcomes of symptomatic discoid meniscus are acceptable [12, 18, 37], the outcomes still vary widely between individuals as a result of diversity in patient factors and treatment modalities [28]. Currently, few studies have reported the influencing factors of postoperative arthroscopy, and the results are inconsistent [11, 12, 19, 26]. Therefore, the present research aims to explore the factors influencing arthroscopic treatment for symptomatic DLM. We identified 20 factors, including gender, body mass index (BMI), and 18 others, that we hypothesized to affect the results of arthroscopic surgeries for symptomatic DLM.

Materials And Methods
Patients were selected according to the inclusion and exclusion criteria. The inclusion criteria were symptomatic discoid meniscus patients who underwent arthroscopic surgery at the Sports Medicine Center of West China Hospital of Sichuan University from September 2008 to September 2015. The exclusion criteria were as follows: patients with missing data; patients lost to follow-up; patients with bilateral knee DLM who underwent an operation; patients with symptomatic discoid medial meniscus, knee ligament injury or knee joint fracture; patients with rheumatoid arthritis or gouty arthritis of the knee joint; and patients with a knee infection. A flow chart of the study is shown in Fig. 1. The following 20 potential influences on the postoperative efficacy of symptomatic DLM treatment were collected from the medical records, imaging data and arthroscopy videos: sex; BMI (kg/m²); work intensity (according to the REFA daily life and work intensity classification [27]); trauma history
The data were statistically analysed using SPSS 23.0. A normality test revealed that the data were not normally distributed. The measurement data and enumeration data are described by the median (M) and the interquartile range (IQR), respectively. The factors that potentially affect the outcomes of symptomatic DLM treatment were explored by analysing the correlation between the above 20 study factors and the 4 functional assessment scale scores. Among the above factors, intra-articular lesions such as DLM type, DLM tear, cartilage damage, etc., were judged by arthroscopy. Preoperative and postoperative knee function were evaluated by Lysholm Knee Scoring Scale [10, 31], the Tegner Activity Score [46], the International Knee Documentation Committee (IKDC) subjective knee evaluation form [21] and the grading scale of Outerbridge [38]; method of surgery (including saucerection, saucerection with repair and subtotal/total meniscectomy); time of first postoperative weight bearing (dichotomized as the first day or second week after surgery); and final follow-up time (months). The severity of cartilage lesion (according to the Outerbridge grade [38]); presence of an articular cartilage lesion (the location of the articular cartilage lesion on the knee joint was specified as the lateral compartment (lateral femoral condyle and lateral tibial plateau), medial compartment (medial femoral condyle and medial tibial plateau), or patellofemoral joint (patella and trochlea) [19]); severity of cartilage lesion (according to the Outerbridge grade [38]) method of surgery (including saucerection, saucerection with repair and subtotal/total meniscectomy); time of first postoperative weight bearing (dichotomized as the first day or second week after surgery); and final follow-up time (months). The scores were obtained through regular follow-up by outpatient visits. The basic characteristics of the included subjects are shown in Table 1. The factors that potentially affect the outcomes of symptomatic DLM treatment were explored by analysing the correlation between the above 20 study factors and the 4 functional assessment scale scores.
and interquartile range (IQR) and by the number of cases (percentage), respectively. The differences between the preoperative and postoperative functional assessments were analysed by the Wilcoxon rank-sum test. For the assessment grades, univariate analysis was conducted by the Mann-Whitney rank sum test and Kruskal-Wallis rank sum test, and multivariate analysis was performed by ordered logistic regression. For two-category data, univariate analysis was conducted by the Mann-Whitney rank sum test and chi-squared test, and multivariate analysis was performed by logistic regression. P < 0.05 was considered statistically significant.

Results

**General characteristics of the subjects**

According to the inclusion and exclusion criteria, 502 patients were ultimately included in our study. There were 353 females (70.3%) and 149 males (29.7%). The median age of onset was 32.0 years (range, 3~80 years; IQR, 26.3), the median duration of symptoms was 10.0 months (range, 0.05~246 months; IQR, 21.0), and the median age at surgery was 34.0 years (range, 4~81 years; IQR, 26.2). A total of 252 (50.2%) left knees and 250 (49.8%) right knees were involved. A total of 360 (71.7%) patients without a history of trauma and 142 (28.3%) with a history of trauma were included. Other baseline patient information is shown in Table 1. Preoperatively, the median Lysholm score was 60 (range, 25~78; IQR, 11), the median Tegner score was 1 (range, 0~3; IQR, 1), and the median IKDC score was 57.6 (range, 26.9~64.9; IQR, 9.7). In addition, the patients were classified as fair (436, 86.9%) or poor (66, 13.1%) according to the Ikeuchi scale. Postoperatively, the median Lysholm score was 95 (range, 50~100; IQR, 14), the median Tegner score was 4 (range, 1~9; IQR, 2), and the median IKDC score was 87.4 (range, 41.4~97.7; IQR, 14.6). In addition, the patients were classified as excellent (341, 67.9%), good (105, 20.9%), fair (44, 8.8%) or poor (12, 2.4%) according to the Ikeuchi scale. In the follow-up, none of the patients required reoperation or had complications after surgery. In terms of the 4 functional assessments, the differences between the preoperative results and postoperative follow-up results were statistically significant (P < 0.001 for all).

**Univariate analysis of the 20 factors studied and the 4 functional assessment scales**

Factors such as sex, BMI, work intensity, trauma history, age of onset, duration of symptoms, age at
surgery, presence of articular cartilage lesion, location of articular cartilage lesion, Outerbridge grade, KL grade and method of surgery may be associated with the Lysholm, Tegner, IKDC and Ikeuchi grades (P < 0.05). The presence of a medial meniscus injury may be associated with the Lysholm, IKDC, and Ikeuchi grades (P<0.05). In addition, there were possible correlations between the time to postoperative weight bearing and the IKDC grade and between the type of DLM and the Ikeuchi grade (P<0.05).

**Multivariate analysis of the 20 factors studied and the 4 functional assessment scales**

Female sex was an influencing factor for Lysholm grade (P=0.002, odds ratio (OR)=2.713, 95% confidence interval (CI): 1.448–5.078), Tegner grade (P=0.001, OR=2.526, 95% CI: 1.489–4.286), IKDC grade (P=0.022, OR=1.735, 95% CI: 1.082–2.784) and Ikeuchi grade (P=0.010, OR=2.164, 95% CI: 1.201–3.900). BMI was negatively correlated with Lysholm grade (P=0.007, OR=1.119, 95% CI: 1.031–1.214) and IKDC grade (P=0.029, OR=1.088, 95% CI: 1.009–1.174). Work intensity was negatively related to IKDC grade (P=0.038, OR=1.492, 95% CI: 1.023–2.175) and Ikeuchi grade (P=0.014, OR=1.689, 95% CI: 1.112–2.563). Age of onset was inversely correlated with Tegner grade (P<0.001, OR=1.109, 95% CI: 1.088–1.131). Symptoms duration and IKDC grade (P=0.002, OR=1.020, 95% CI: 1.007–1.033) had an inverse correlation. Lack of cartilage lesions was a protective factor in terms of Tegner grade (P<0.001, OR=0.261, 95% CI: 0.142–0.479). The Outerbridge grade of the articular cartilage lesion was negatively correlated with the Lysholm grade (P=0.016, OR=1.589, 95% CI: 1.090–2.316) and Ikeuchi grade (P=0.017, OR=1.582, 95% CI: 1.087–2.305). Saucerization with repair was a risk factor for Ikeuchi grade (P=0.037, OR=4.328, 95% CI: 1.090-17.167) compared to subtotal/total meniscectomy. There were no significant differences between the other study factors and the results of the 4 functional assessment scales (Tables 2-5).

**Discussion**

*Female sex, high BMI, and high work intensity were risk factors for poor postoperative outcomes. Trauma history and the involved knee joint were not correlated with postoperative outcomes*

Female sex is a risk factor for many orthopaedic diseases, but its correlation with the postoperative
efficacy of DLM has been controversial to date. Chen et al. [12] and Kose et al. [26] found that gender differences had no significant effect on postoperative efficacy of DLM, which may be related to the small sample sizes in those studies (n=39 and n=48, respectively). However, Ahn et al. [5] demonstrated that sex may affect postoperative outcomes and that male sex was a protective factor by evaluating 260 patients with DLM. This study found that sex was correlated with the results of these 4 functional assessment scales (P < 0.05) and that female sex was a risk factor by investigating 520 patients with DLM. Compared with males, females have a reduced volume of knee articular cartilage volume and an increased Q angle [14, 15, 18]; thus, females are more prone to cartilage lesions and osteoarthritis [20], which may be the reason for poor postoperative clinical outcomes in women. Fu et al. [18] found that patients with BMI >23.0 kg/m\(^2\) were at an increased risk of articular cartilage lesions. However, Ahn et al. [2] believed that high BMI was not a risk factor for cartilage degeneration as observed by imaging. This study found that the higher the BMI, the lower the Lysholm, IKDC, and Ikeuchi grades may be. Obesity can lead to meniscus compression, pathological changes and loss of articular cartilage [17], which ultimately results in knee osteoarthritis and poor postoperative efficacy of symptomatic DLM [43]. In addition, the impact of work intensity on the postoperative efficacy of DLM was similar to that of BMI, which may be because knee joint activity, load-bearing capacity and cartilage lesions were positively correlated with work intensity.

Studies have shown that there is no significant correlation between trauma history and the presence of knee cartilage lesions [16, 18]. Our study also found that a history of trauma did not affect the postoperative outcome. Moreover, we also found that there were no significant differences in these 4 functional assessment scales between the left and right knee joints in patients with symptomatic DLM, indicating that the knee joint involved (left or right) may have no significant effect on the postoperative outcome.

*Postoperative outcomes are best when the age of onset is early, the duration of symptoms is short, and the surgical intervention is prompt*

Numerous studies have found that the younger the age of onset of symptomatic DLM, the shorter the duration of symptoms (especially <12 months), and the earlier the surgical intervention, the better...
the prognosis tends to be [5, 12, 28, 37, 47]. This may be due to the lower risk of postoperative chondromalacia resulting from the younger onset age and lower risk of injury or degeneration in lateral cartilage and residual meniscus arising from shorter duration of symptoms [2, 16, 18, 28, 37]. In addition, older age at surgery may be associated with more obvious postoperative articular cartilage degeneration and imaging changes [5, 12, 19, 26, 31, 35, 47], and lower adaptability of the knee joint to pressure changes [45]. The current study also found that age of onset and duration of symptoms were negatively correlated with Tegner activity grading (P < 0.001, OR = 1.109; 95% CI: 1.008-1.131) and IKDC functional grading (P = 0.02, OR = 1.020, 95% CI: 1.007-1.033). However, the age of surgery in this study was not an independent risk factor for postoperative clinical outcomes, which may be due to the impact of the age of onset and duration of symptoms on age of surgery in statistical analysis.

**DLM type, DLM tear, location of DLM tear, and type of DLM tear have no significant correlation with postoperative outcomes**

A considerable number of studies have shown that DLM type, DLM tear, location of DLM tear, and type of DLM tear have no significant effect on postoperative efficacy [12, 26, 28]. The results of our study are consistent with the above reports in the literature. Given that no significant difference existed among different types of discoid meniscus in the incidence of articular cartilage lesions [16, 18] or postoperative discoid meniscus morphology [7], the influence of the discoid meniscus type on postoperative efficacy may not be significant. However, Zhang et al. [49] found that DLM tears not only affect the cartilage in the lateral compartment of the knee joint but also cause degeneration of the articular cartilage in the medial compartment by compressing the medial meniscus, leading to osteoarthritis and poor postoperative outcomes. However, Ding et al. [16] and Kose et al. [26] asserted that discoid meniscus injuries are not correlated with articular cartilage lesions. Additionally, although meniscus injury may cause articular cartilage degeneration in the long term [16], we also found that the diagnosis and treatment of meniscus injury is often immediate because of its heavy symptoms; thus, a difference in cartilage damage was not observed in terms of whether the DLM tear was present at the time of surgery. In addition, Ahn et al. [2] found that horizontal tears in the discoid
meniscus may accelerate the radiological progression of postoperative KL grade 3/4 osteoarthritis, which may be because the duration of symptoms of horizontal meniscus tear, a degenerative tear, is longer and the postoperative residual meniscus tissue is less plentiful and more fragile than for other tear types. In contrast, Chen et al. [12] and Badlani et al. [8] asserted that radial tears lead to poor postoperative outcomes. However, the present study and a study by Fu et al. [18] failed to find that the severity of cartilage damage is related to the type of DLM tear, which may be because the difference in thickness between DLM and a normal meniscus is not obvious after a layer of horizontal meniscus tear is removed, since the discoid meniscus is thicker than the normal meniscus. In addition, DLM itself is at an increased risk of tearing, and the symptom duration of horizontal tearing may not be significantly different from other tear types [34, 40].

**DLM combined with knee cartilage injury and severity of the cartilage lesion significantly affected the postoperative efficacy, but KL grade, location of the articular cartilage lesion and the complication of medial meniscus tear were not significantly correlated with postoperative efficacy**

The results of this study suggest that articular cartilage injury is an influencing factor for Tegner grade. Although the clinical manifestations of an articular cartilage lesion may not be obvious in the short term, most patients will eventually have knee degeneration associated with cartilage damage, which leads to severe and irreversible osteoarthritis, thus drastically affecting knee function [44]. We also found that the Outerbridge grade of the cartilage lesion was negatively correlated with the Lysholm grade (P=0.016, OR=1.589; 95% CI: 1.090–2.316) and Ikeuchi grade (P=0.017, OR=1.582; 95% CI: 1.087–2.305). Hiroshi et al. [22] assert that the Outerbridge grade can directly reflect the severity of the cartilage lesions and that the Outerbridge grade is the decisive factor affecting the long-term outcomes after meniscal surgery. Link et al. [32] reported that the KL grade was significantly correlated with Outerbridge grade, which has an unclear effect on the postoperative efficacy of DLM treatment. Our study also did not find a relationship between KL grade and postoperative outcome, which may be because X-rays are not highly sensitive to cartilage lesions [6] and because early joint space reduction is secondary not to articular cartilage thinning but to
meniscal compression, indicating that X-rays a reliable technique to evaluate articular cartilage loss [1]. In addition, we found that the location of the cartilage lesion did not affect the postoperative outcomes of DLM patients. Fu et al. [18] and Kose et al. [26] found no significant difference in the degree of cartilage damage between the different compartments involved; therefore, the effect of location of the cartilage lesion on postoperative outcomes may not be noticeable. Moreover, Kose et al. [26] have shown that the presence of medial meniscus tears had no impact on postoperative outcomes, which is similar to the results of our study. In this study, few patients had medial meniscus tears. The impact of medial meniscus tears on postoperative outcomes needs to be examined further with a larger sample size.

**Postoperative outcome was not affected by the time of first postoperative weight bearing or the final follow-up time but was affected by the surgical method**

The currently available arthroscopic treatment methods for symptomatic discoid meniscus include saucerization (partial meniscectomy), saucerization with repair and subtotal/total meniscectomy [2, 9, 24, 45, 47]. The choice of surgical methods is mainly determined by the condition of the patient's discoid meniscus injury [12]. In this study, if the peripheral rim (the fibrous loop of DLM) is complete, then saucerization is used; if the structure is incomplete, subtotal/total meniscectomy is conducted; if the structure is complete and is characterized by instability or tearing of a peripheral rim or a repairable tear in the red zone, saucerization with repair is performed. In addition, the surgical procedures for all patients were performed by the same senior physician, and the surgical technique was reliable and stable. In the follow-up, none of the patients required reoperation or had complications after surgery. We found that saucerization with repair is a stronger influencing factor for the Ikeuchi grade (P=0.037, OR=4.328, 95% CI: 1.090–17.167) than subtotal/total meniscectomy is. Instead, Ahn et al. [4] reported that arthroscopic partial meniscectomy with repair has better efficacy than subtotal/total meniscectomy in children with symptomatic DLM, which may be because partial meniscectomy with repair can prevent early degenerative changes in the joint [35]. However, Lee et al. [28] believe that residual discoid meniscus tissue is prone to degeneration and re-injury due to an abnormally fibrous structure, which may lead to adverse clinical effects. Moreover, only 16
(3.2%) patients, including children and adults, underwent saucerization with repair in this study. In addition, considering the high cost and uncertain effectiveness of repair, some scholars do not recommend repair of the abnormal anatomy in a torn DLM [42]. Regarding the postoperative outcomes between saucerization and subtotal or total meniscectomy, we did not find differences. Some scholars also have not found differences in clinical outcomes between partial meniscectomy and total meniscectomy in the short or medium term, but the clinical efficacy of partial meniscectomy is better than that of subtotal or total meniscectomy in the long term [2, 3, 9, 24, 31, 42, 45, 48]. Interestingly, Ikeuchi [23] reported that the results of partial meniscectomy were significantly worse than those of total meniscectomy. The discrepancy between these studies may be because the choice of surgical methods was affected by factors such as age at surgery, tearing status and the presence of cartilage lesions as well as the small sample sizes for subtotal or total meniscectomy. Additionally, we did not compare the postoperative outcomes between saucerization and partial meniscectomy with repair. A systematic review found a difference in postoperative outcomes between partial meniscectomy with repair and saucerization, but these two methods both had significantly better outcomes than total meniscectomy [42]. In contrast, Lee et al. [29] and Wong and Wang [47] concluded that there was no significant difference in postoperative outcomes among these three surgical methods.

For DLM patients, weight-bearing activities soon after surgery are conducive to self-care and improvement of knee function [25]. In this study, with the exception of 16 (3.2%) patients who underwent meniscus repair and 43 (8.6%) patients who underwent microfracture who gradually started weight-bearing activities 4-8 weeks after surgery [44], the patients who underwent surgery were divided into two load-bearing regimens, one used before 2014 and the other used from 2014 onward. Patients on the former regimen gradually started weight-bearing activities in the second week after surgery, and those on the latter regimen gradually started weight-bearing activities the first day after surgery. The results showed that the time of postoperative weight bearing did not affect the efficacy of symptomatic DLM treatment. In view of the fact that early ambulation and weight-bearing activities are especially beneficial for restoring self-care ability and improving surgical
satisfaction, we recommend functional exercise as soon as possible. A longer follow-up is believed to be associated with more severe articular cartilage degeneration and clinical symptoms and worse knee joint function [28, 31]. In our study, the median follow-up time was 75.4 (range, 41~123; IQR, 33.7) months. The analysis showed that the final follow-up time was not an influencing factor for the postoperative efficacy of symptomatic DLM treatment. This result may be due to the small number of patients with follow-up periods over 120 months.

**Limitations**

We acknowledge that there are some limitations to our study. First, although only 502 patients were included, the study analysed 20 predictors and used 4 functional assessment scales. Each predictor was divided into two or more groups, and each scale was classified into four or more layers. Moreover, it was necessary to merge some layers with very few cases in the event of small sample sizes. These factors may impact the statistical analysis results. Second, each functional assessment scale has its own characteristics and limitations [10, 21, 23, 33, 46]. Combining these four functional assessment methods can make the assessment more comprehensive but can also increase the risk of false positive results. Third, the postoperative efficacy evaluation in this study did not analyse the imaging changes at the final follow-up and instead evaluated only the subjective functional parameters; thus, there was no objective evaluation index that corresponded to the postoperative outcome. Finally, this study is only a retrospective multivariate analysis, and the conclusions need to be further confirmed by prospective studies.

**Conclusion**

Arthroscopic treatment of symptomatic DLM is safe and effective. Female sex, cartilage lesions and saucerization with repair may be related to unfavourable postoperative outcomes. Clinical efficacy may worsen with increasing BMI, work intensity, symptom duration, age of onset and severity of cartilage lesions (Outerbridge grade).

**Declarations**

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**Availability of data and materials**
The patient's personal information and imaging data of following-up were stored in the disc. The data are available from the corresponding author upon request. G Chen will be contact to provide data and materials.

**Authors’ contributions**
S.J Yang and Z.J Ding participated in the surgery, collected clinical data, major contributor to writing and editing the manuscript. Y.Xue initiated the work and collected clinical data. J.Li was the surgeon of the operation, responsible for the screening of the patients and postoperative follow-up. G.Chen participated in the entire process, including surgery, follow-up of the patients, data collection, writing and revision of this article. All authors have read and approved the final manuscript.

**Ethics approval and consent to participate**
Ethical approval was obtained from the Human and Ethics Committee for Medical Research at Sichuan University in accordance with the Declaration of Helsinki (Ethical Committee Approval: Version number-1.1 Date 26st October 2016 ). Medical informed consent was obtained for all patients prior to participation.

**Competing interest**
The authors declared that they have no competing interests.

**Consent for publication**
All authors agree to the publication of the article. The patient himself and his family agreed to publish and disclose the clinical data of the patient with written consent.

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Abbreviations

DLM: Discoid lateral meniscus; BMI: body mass index; IKDC: International Knee Documentation Committee; K-L: Kellgren-Lawrence; MRI: magnetic resonance imaging; M: median; OR: odds ratio; IQR: interquartile range CI: confidence interval.

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Tables
Table 1. Basic characteristics of the included patients
| Demographic details | N (%)/M (range; IQR)† | Demographic details | N(%)/M (range; IQR)† | Demographic details | N (%)/M (range; IQR)† |
|---------------------|----------------------|---------------------|----------------------|---------------------|----------------------|
| Patients            | 502                  | Anterior horn       | 27 (5.4%)            | Subtotal/total meniscectomy | 76 (15.1%)          |
|                     |                      | Posterior horn      | 41 (8.2%)            | Time of postoperative weight bearing | 161 (30.1%)          |
| Sex                 |                      | Body                | 204 (40.6%)          | First day after surgery | 341 (67.9%)          |
| Female              | 353 (70.3%)          | Body and anterior horn | 32 (6.4%)          | Second week after surgery | 75.4 (range, 42~123; 33.7) |
| Male                | 149 (29.7%)          | Body and posterior horn | 67 (13.3%)        | Final follow-up time (months) | 75.4 (range, 42~123; 33.7) |
| BMI (kg/m²)         | 22.03 (range, 13.8~44.4; 4.3) | Total tear          | 87 (17.3%)          | Lysholm score, preoperative | 60 (range, 25 ~78; 11) |
| Work intensity      |                      | Anterior horn and posterior horn | 6 (1.2%)          | 70 ~ 79 (fair) | 78(15.5%) |
| Grade 0             | 27 (5.6%)            | Type of DLM tear    | 38 (7.6%)           | < 70 (poor) | 424(84.5%) |
| Grade 1             | 212 (42.2%)          | No tear             | 484 (96.4%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Grade 2             | 240 (47.8%)          | Longitudinal (/bucket handle) tear | 171 (34.1%) | 80 ~ 89 (excellent) | 90 (17.9%) |
| Grade 3             | 22 (4.4%)            | Horizontal tear     | 154 (30.7%)         | Final follow-up time (months) | 75.4 (range, 42~123; 33.7) |
| Grade 4             | 1 (0.2%)             | Oblique tear        | 10 (2.0%)           | 70 ~ 79 (fair) | 35 (7.0%) |
| Trauma history      | No                   | Transverse (/radial) tear | 45 (9.0%)          | < 70 (poor) | 23 (4.6%) |
|                     | 360 (71.7%)          | Variant tear        | 84 (16.7%)          | Tegner score, préopérateur 0 ~ 4 | 502(100.0%) |
|                     |                      | Yes                 | 144 (28.7%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Involving knee joint | No                   | Medial meniscus tear | 484 (96.4%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Left                | 252 (50.2%)          | Knee cartilage injury No | 18 (3.6%)          | Tegner score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Right               | 250 (49.8%)          | No                  | 358 (71.3%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Age of onset        | No                   | Transverse (/radial) tear | 45 (9.0%)          | < 70 (poor) | 23 (4.6%) |
|                     | 32.0 (range, 3~80; 26.3) | Variant tear        | 84 (16.7%)          | 424(84.5%) |
|                     |                      | Yes                 | 144 (28.7%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Symptoms duration   | 10.0 (range, 0.05~246; 21.0) | Location of the articular cartilage lesion | 144 (28.7%) | < 70 (poor) | 502 (100.0%) |
| (months)            |                      | No injury           | 358 (71.3%)         | 424(84.5%) |
| Age at surgery      | No                   | Location of the articular cartilage lesion | 144 (28.7%) | < 70 (poor) | 502 (100.0%) |
| (years)             | 34.0 (range, 4~81; 26.2) | IKDC score at final follow-up | 87.4 (range, 41.4~97.7; 14.6) | 199 (39.6%) |
| KL grade            | No                   | IKDC score at final follow-up | 87.4 (range, 41.4~97.7; 14.6) | 199 (39.6%) |
|                     | 375 (74.7%)          | Lateral compartment | 100 (19.9%)         | 80 ~ 89 (excellent) | 164 (32.7%) |
| Level 0             |                      | Medial compartment  | 18 (3.6%)           | 80 ~ 89 (excellent) | 164 (32.7%) |
| Level I             | 56 (11.2%)           | Patellofemoral joint | 9 (1.8%)           | 70 ~ 79 (fair) | 84 (16.7%) |
| Level II            | 44 (8.8%)            | Two or more compartments | 3 (0.6%)          | < 70 (poor) | 55 (11.0%) |
| Level III           | 23 (4.6%)            | No injury           | 358 (71.3%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Level IV DLM type   | 4 (0.8%)             | Outerbridge grade   | 358 (71.3%)         | IKDC score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| Complete            | 423 (84.3%)          | Level I             | 219 (45.9%)         | Tegner score, préopérateur 0 ~ 4 | 502(100.0%) |
| Incomplete DLM tear | No                   | Level II            | 52 (10.4%)          | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
|                     | 38 (7.6%)            | Level III           | 23 (4.6%)           | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
|                     |                      | Level IV            | 40 (8.0%)           | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
|                     | 464 (92.4%)          | Method of surgery   | 410 (81.7%)         | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |
| No tear             | 38 (7.6%)            | Saucerization       | 16 (3.2%)           | Lysholm score at final follow-up ≥ 90 (good) | 354 (70.5%) |

BMI: body mass index; KL grade: Kellgren–Lawrence grade; DLM: discoid lateral meniscus; IKDC: International Knee Documentation Committee; † N: number; M: median; IQR: interquartile range

Table 2. Multivariate analysis of research factors and Lysholm functional grading
| Variable                        | β     | S. E.  | Wald  | P   | OR   | 95% CI          | Lower | Upper |
|--------------------------------|-------|--------|-------|-----|------|-----------------|-------|-------|
|                               |       |        |       |     |      |                 |       |       |
| BMI                            | 0.112 | 0.042  | 7.295 | 0   | 1.119| 1.031 - 1.214   |       |       |
| Work intensity                 | 0.125 | 0.195  | 0.415 | 0   | 1.133| 0.774 - 1.660   |       |       |
| Age of onset                   | -0.02 | 0.152  | 0.017 | 0   | 0.980| 0.728 - 1.320   |       |       |
| Symptoms duration              | 0.005 | 0.013  | 0.145 | 0   | 1.005| 0.979 - 1.030   |       |       |
| Age at surgery                 | 0.068 | 0.152  | 0.202 | 0   | 1.070| 0.795 - 1.441   |       |       |
| KL grade                       | 0.125 | 0.195  | 0.415 | 0   | 1.133| 0.774 - 1.660   |       |       |
| Outerbridge grade              | 0.463 | 0.192  | 5.803 | 0   | 1.589| 1.090 - 2.316   |       |       |
| Sex                            |       |        |       |     |      |                 |       |       |
| Female                         | 0.998 | 0.321  | 9.72  | 0   | 2.713| 1.448 - 5.078   |       |       |
| Male‡                          | -     | -      | -     | -   | 1.000| -               |       |       |
| History of trauma              |       |        |       |     |      |                 |       |       |
| No                             | 0.539 | 0.291  | 3.432 | 0   | 1.714| 0.969 - 3.031   |       |       |
| Yes‡                           | -     | -      | -     | -   | 1.000| -               |       |       |
| Medial meniscus tear           |       |        |       |     |      |                 |       |       |
| No                             | -1.037| 0.639  | 2.635 | 0   | 0.355| 0.101 - 1.240   |       |       |
| Yes‡                           | -     | -      | -     | -   | 1.000| -               |       |       |
| Knee cartilage injury          |       |        |       |     |      |                 |       |       |
| No                             | -0.557| 0.797  | 0.489 | 0   | 0.573| 0.120 - 2.732   |       |       |
| Yes‡                           | -     | -      | -     | -   | 1.000| -               |       |       |
| Location of the articular cartilage lesion | β   | S.E. | Wald  | P      | OR   | 95% CI   |
|-------------------------------------------|-----|------|-------|--------|------|----------|
| Lateral compartment                       | 0.096 | 0.56 | 0.029 | 0.818 | 1.101 | 0.366 - 3.304 |
| Medial compartment                        | -0.526 | 0.85 | 0.375 | 0.565 | 0.591 | 0.110 - 3.180 |
| Patellofemoral joint                      | -0.078 | 0.87 | 0.008 | 0.925 | 0.375 | 0.165 - 5.176 |
| Any two or more compartments‡            | -    | -    | -     | -     | 1.000 | -        |
| Method of surgery                         | -    | -    | -     | -     | 1.000 | -        |
| Saucerization                             | -0.452 | 0.35 | 1.589 | 0.207 | 0.636 | 0.315 - 1.285 |
| Saucerization with repair                 | 0.734 | 0.74 | 0.98  | 0.322 | 2.083 | 0.487 - 8.917 |
| Subtotal/total meniscectomy‡              | -    | -    | -     | -     | 1.000 | -        |

BMI: body mass index; KL grade: Kellgren-Lawrence grade; ‡reference group; *statistically significant (P < .05).

Table 3 Multivariate analysis of research factors and Tegner activity grading

| Variable                  | β     | S.E. | Wald  | P   | OR  | 95% CI   |
|---------------------------|-------|------|-------|-----|-----|----------|
| Age of onset              | 0.104 | 0.01 | 105.782 | 0.000* | 1.109 | 1.088 - 1.131 |
| Sex                       |       |      |       |     |     |          |
| Female                    | 0.927 | 0.27 | 11.809 | 0.001* | 2.526 | 1.489 - 4.286 |
| Male‡                     | -     | -    | -     | -   | 1.000 | -        |
| Knee cartilage injury     |       |      |       |     |     |          |
| No                        | -1.345 | 0.311 | 18.736 | 0.000* | 0.261 | 0.142 - 0.479 |
| Yes‡                      | -     | -    | -     | -   | 1.000 | -        |

‡reference group; *statistically significant (P < .05).

Table 4. Multivariate analysis of research factors and IKDC functional grading
| Variable                      | $\beta$ | S.E. | Wald  | P       | OR    | 95% CI          |
|-------------------------------|---------|------|-------|---------|-------|-----------------|
|                               |         |      |       |         |       | Lower | Upper |
| BMI                           | 0.084   | 0.039| 4.763 | 0.029*  | 1.088 | 1.009 | 1.174 |
| Work intensity                | 0.400   | 0.192| 4.320 | 0.038*  | 1.492 | 1.023 | 2.175 |
| Age of onset                  | 0.106   | 0.068| 2.402 | 0.121   | 1.112 | 0.972 | 1.270 |
| Symptoms duration             | 0.020   | 0.006| 9.718 | 0.002*  | 1.020 | 1.007 | 1.033 |
| Age at surgery                | -0.019  | 0.067| 0.077 | 0.781   | 0.981 | 0.861 | 1.120 |
| KL grade                      | -0.053  | 0.202| 0.068 | 0.794   | 0.948 | 0.638 | 1.409 |
| Outerbridge grade             | 0.323   | 0.210| 2.382 | 0.123   | 1.381 | 0.917 | 2.083 |
| Sex                           |         |      |       |         |       | Lower | Upper |
| Female                        | 0.551   | 0.241| 5.231 | 0.022*  | 1.735 | 1.082 | 2.784 |
| Male‡                         | -       | -    | -     | -       | 1.000 | -    | -    |
| History of trauma             |         |      |       |         |       | Lower | Upper |
| No                            | 0.162   | 0.229| 0.502 | 0.479   | 1.176 | 0.751 | 1.840 |
| Yes‡                          | -       | -    | -     | -       | 1.000 | -    | -    |
| Medial meniscus tear          |         |      |       |         |       | Lower | Upper |
| No                            | 0.900   | 0.671| 1.799 | 0.180   | 2.460 | 0.660 | 9.161 |
| Yes‡                          | -       | -    | -     | -       | 1.000 | -    | -    |
| Knee cartilage injury         |         |      |       |         |       | Lower | Upper |
| No                            | -1.749  | 1.037| 2.844 | 0.092   | 0.174 | 0.023 | 1.328 |
| Yes‡                          | -       | -    | -     | -       | 1.000 | -    | -    |
| Location of the articular cartilage lesion | | | | | | |
| Lateral compartment           | -1.052  | 0.822| 1.641 | 0.200   | 0.349 | 0.070 | 1.747 |
| Medial compartment            | -1.459  | 1.101| 1.756 | 0.185   | 0.232 | 0.027 | 2.012 |
| Patellofemoral joint          | -0.491  | 1.368| 0.129 | 0.720   | 0.612 | 0.042 | 8.935 |
| Any two or more compartments‡| -       | -    | -     | -       | 1.000 | -    | -    |
| Method of surgery             |         |      |       |         |       | Lower | Upper |
| Saucerization                 | 0.217   | 0.377| 0.330 | 0.565   | 1.242 | 0.593 | 2.604 |
| Saucerization with repair     | 1.131   | 0.688| 2.702 | 0.100   | 3.099 | 0.804 | 11.941 |
| Subtotal/total meniscectomy‡  | -       | -    | -     | -       | 1.000 | -    | -    |
| Time of postoperative weight bearing | | | | | | |
| First day after surgery       | 0.232   | 0.227| 1.049 | 0.306   | 1.261 | 0.809 | 1.968 |
| Second week after surgery‡    | -       | -    | -     | -       | 1.000 | -    | -    |

IKDC: International Knee Documentation Committee; BMI: body mass index; KL grade: Kellgren-Lawrence grade; ‡reference group; *statistically significant (P < .05).

Table 5. Multivariate analysis of research factors and Ikeuchi functional grading
| Variable                          | $\beta$ | S.E. | Wald  | $P$   | OR   | 95% CI Lower | 95% CI Upper |
|----------------------------------|---------|------|-------|-------|------|--------------|--------------|
| BMI                              | 0.004   | 0.113| 0.002 | 0.969 | 1.004| 0.805        | 1.254        |
| Work intensity                   | 0.524   | 0.213| 6.032 | 0.014*| 1.689| 1.112        | 2.563        |
| Age of onset                     | 0.004   | 0.113| 0.002 | 0.969 | 1.004| 0.805        | 1.254        |
| Symptoms duration                | 0.009   | 0.01 | 0.785 | 0.375 | 1.009| 0.989        | 1.028        |
| Age at surgery                   | 0.042   | 0.112| 0.141 | 0.707 | 1.043| 0.837        | 1.300        |
| KL grade                         | 0.233   | 0.194| 1.446 | 0.229 | 1.262| 0.863        | 1.844        |
| Outerbridge grade                | 0.459   | 0.192| 5.729 | 0.017*| 1.582| 1.087        | 2.305        |
| Sex                              |         |      |       |       |      |              |              |
| Female                           | 0.772   | 0.3   | 6.607 | 0.010*| 2.164| 1.201        | 3.900        |
| Male‡                            | -       | -    | -     | -     | 1.000| -            | -            |
| History of trauma                |         |      |       |       |      |              |              |
| No                               | 0.290   | 0.279| 1.085 | 0.298 | 1.336| 0.774        | 2.309        |
| Yes‡                             | -       | -    | -     | -     | 1.000| -            | -            |
| DLM type                         |         |      |       |       |      |              |              |
| Complete                         | -0.110  | 0.318| 0.119 | 0.730 | 0.896| 0.480        | 1.672        |
| Incomplete and Wrisberg‡         | -       | -    | -     | -     | 1.000| -            | -            |
| Medial meniscus tear             |         |      |       |       |      |              |              |
| No                               | -0.608  | 0.607| 1.003 | 0.317 | 0.544| 0.165        | 1.790        |
| Yes‡                             | -       | -    | -     | -     | 1.000| -            | -            |
| Knee cartilage injury            |         |      |       |       |      |              |              |
| No                               | -0.375  | 0.799| 0.22  | 0.639 | 0.687| 0.144        | 3.290        |
| Yes‡                             | -       | -    | -     | -     | 1.000| -            | -            |
| Location of the articular cartilage lesion    |         |      |       |       |      |              |              |
| Lateral compartment              | -0.042  | 0.556| 0.006 | 0.940 | 0.959| 0.323        | 2.849        |
| Medial compartment               | -0.150  | 0.853| 0.031 | 0.860 | 0.861| 0.162        | 4.577        |
| Patellofemoral joint             | 0.445   | 0.926| 0.231 | 0.631 | 1.560| 0.254        | 9.593        |
| Any two or more compartments‡   | -       | -    | -     | -     | 1.000| -            | -            |
| Method of surgery                |         |      |       |       |      |              |              |
| Saucerization                    | -0.315  | 0.352| 0.801 | 0.371 | 0.730| 0.366        | 1.455        |
| Saucerization with repair        | 1.465   | 0.703| 4.334 | 0.037*| 4.328| 1.090        | 17.167       |
| Subtotal/total resection‡        | -       | -    | -     | -     | 1.000| -            | -            |

BMI: body mass index; KL grade: Kellgren-Lawrence grade; ‡reference group; *statistically significant (P < .05).

Figures
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