Observational Study

Medicine®

OPEN

The adaptive change of patellofemoral joint after arthroscopic discoid lateral meniscus plasty

An observational study

Jiangtao Dong, MD[a], Hongtao Xu, MD[a], Guorong Jin, MD[a], Dongmei Xin, MD[b], Jian Zhang, MD[c], Kai Kang, MD[a], Shijun Gao, MD[a], Baicheng Chen, MD[a,*], Yong Shen, MD[a,*]

Abstract

The purpose of this study was to investigate the patellofemoral joint adaptive changes after discoid lateral meniscus (DLM) plasty.

Forty-one patients with unilateral complete type DLM tears were included in this study. Demographic variables, including gender, age, body mass index (BMI), injury to operation interval, type of injury, and follow-up time, were recorded. The evolution of physical examination, imaging index, and functional score were analyzed by Chi-squared test, Wilcoxon signed ranks test, and Friedman test. Mann–Whitney test was used to analyze the difference at different time points between group PFI > 1.6 and PFI < 1.6.

After the patients received arthroscopic DLM plasty, the positive rate of Patella grinding test increased from 19.5% to 29.3%, and it showed significant increased at last follow-up time point (48.8%) ($P = .005$). Mechanical axis deviation (MAD) significant decreased from -0.7 ± 2.1 mm to -9.4 ± 3.2 mm ($P < .001$). Lateral patellofemoral angle (LPFA) and lateral shift distance (LSD), respectively, decreased from $11.9 \pm 5.8°$ and 1.0 ± 4.0 mm to $7.2 \pm 4.5°$ and -0.5 ± 3.3 mm ($P < .001$). Patellofemoral index (PFI) increased from 1.7 ± 0.3 to 1.9 ± 0.4 ($P < .001$). Kujala score and Lysholm score, respectively, increased from 65.9 ± 10.0 and 85.2 ± 6.4 mm to 61.8 ± 10.2 and 89.5 ± 5.0 ($P < .001$). Only LSD in group > 1.6 were significant lower than those in group < 1.6 (>1.6: -1.5 ± 2.8, -1.6 ± 2.7, -1.5 ± 2.6; <1.6: 0.8 ± 3.4, 0.4 ± 3.6, 0.6 ± 2.8. $P = .010, .038, .011$) at the 3 postoperative follow-up time points.

After arthroscopic plasty for complete type DLM which decreased the thickness and width of the residual meniscus, in turn causing the varus deformity significantly decreased or a valgus inclination developed. Moreover, the consequent changes of patellofemoral joint caused a certain amount of patellar tilt and patellar dislocation, might aggravated the symptomatic anterolateral knee pain or the lateral patellar compression syndrome.

Abbreviations: BMI = body mass index, CT = computed tomography, DLM = discoid lateral meniscus, LPFA = lateral patellofemoral angle, LSD = lateral shift distance, MAD = mechanical axis deviation, MRI = magnetic resonance imaging, PFI = patellofemoral index, SD = standard deviation.

Keywords: discoid lateral meniscus, lateral patellofemoral angle, lateral shift distance, mechanical axis deviation, patellofemoral index, patellofemoral joint

Editor: Jianxun Ding.

JD and HX contributed equally to this study.

Ethics approval and consent to participate: The ethical approval was not necessary, because this study was an observational study. So patient consent was not required due to the retrospective nature of the study.

Consent for publication: Not applicable.

Availability of data and materials: The datasets supporting the conclusions of this article are included within the article.

The authors have no conflicts of interest to disclose.

[a] The Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, [b] Hospital of TCM, [c] People's Hospital of Ri Zhao, Rizhao, Shandong, People's Republic of China.

[*] Correspondence: Yong Shen and Baicheng Chen, The Third Hospital of Hebei Medical University, No. 139 Ziqiang Road, Shijiazhuang 050000, Hebei, People's Republic of China (e-mails: hbsyshenyong@sina.com; hbsychenbaicheng@163.com).

Medicine (2018) 97:6(e9827)

Received: 23 June 2017 / Received in final form: 9 January 2018 / Accepted: 17 January 2018

http://dx.doi.org/10.1097/MD.0000000000009827

1. Introduction

Discoid lateral meniscus (DLM) in the knee is a common anatomic morphologic variant which has a lower incidence in the United States (3–5%) and Europe (0.4–5%).[1,2] However, it has a relatively higher incidence (5–20%) in Asia. Most DLM are asymptomatic in pediatric population and younger patients may present with the snapping syndrome. Because DLM usually with hypertrophy and wide of meniscus fibrous cartilage, it may be susceptible to meniscus tears or knee stick.[3] Meanwhile, its morphologic variant also changes the stress distribution and relate to the knee osteoarthritis.[4]

The surgical principles of treating torn or damaged menisci evolved to their repair and preservation whenever possible. It aimed to improve patient outcomes and diminish degenerative damage of long-term.[5] However, meniscus repair or suture mainly applies to minor meniscus tears. According to the type and location of meniscus tear, most of them have to accept total, subtotal, or partial meniscectomy.[6] As one of meniscectomy, DLM plasty has better clinical effects on the treatment of discoid meniscus tear and can be regarded as one of the operational option.

In 1962, Watanabe performed the first arthroscopic meniscectomy and it was increasing acceptance and promotion and dissemination.[7] Guettler et al[8] pointed the fact that even a relatively small degree change of the lower limb alignment could cause a dramatic alteration in articular surface contact pressure. Not only that, meniscectomy also have produced great dispute and last now. It was concerned by the scholars that meniscectomy leads to degenerative changes.[9–11] Postoperative evaluations of DLM plasty have been mainly focused on the assessment of joint function and alleviation of preoperative symptoms.[12] But to our knowledge, no study has solely focused on possible alterations in the patellofemoral joint after DLM plasty in middle-aged and young patients.

This study aimed to evaluate the imaging changes in patellofemoral joint and clinical knee function evaluation between preoperative and postoperative DLM plasty. Our hypothesis was that the patellar would significant outward moving and inclining after DLM plasty and cause patellofemoral joint pain symptom. Moreover, these adaptive changes have a slowly evolving progress in long-term observation.

2. Methods

2.1. Participants

This observational study (Level of Evidence 3) was conducted in our institution. From November 2010 to October 2014, a total of 41 patients with unilateral complete type DLM tears confirmed by magnetic resonance imaging (MRI) and arthroscopy were enrolled in the study. Each patient was asked to allow us to examine at the time of symptomatic knee surgery and at follow-up time, and those who agreed were included. The inclusion criteria were: unilateral complete type DLM tear with arthroscopic plasty, the injury was confirmed by MRI. To exclude articular cartilage damage-related chondral progression of osteoarthritis, patients with articular cartilage injury or knee surgery history were excluded from this study. There were 23 females and 18 males with a mean age of 26.7 ± 9.2 years in this study. And there were 24 left knees and 17 right knees. The injury to arthroscopic operation interval averaged 22.3 ± 11.5 days. The type of injury was classified into sprain or fall (29 knees), sports injury (9 knees), and traffic accident (3 knees). All patients included were performed by senior surgeons who had at least 10 years of experience in arthroscopic operation.

2.2. Study procedures

Data of 41 patients were collected and analyzed before surgery and at multiple follow-up times. Patients were evaluated with imaging index and functional score preoperatively and postoperatively. Moreover, patients were checked with physical examination, including McMurray test and Patella grinding test. The 41 patients were divided into 2 groups based on the patellofemoral index (PFI) >1.6 or <1.6. The clinical results were further analyzed between these 2 groups.

2.3. Preoperative evaluation in symptomatic knees

Preoperatively, patients with DLM tear were confirmed by use of 1.5-T MRI scans. According to the Watanabe classification, the morphologic types of DLMs were classified into complete, incomplete, or Wrisberg type. Only complete type DLMs were included into this study because incomplete type was difficult to define its coverage ratio of tibial plateau and the Wrisberg type, which is described as a normal-shaped meniscus lacking a posterior coronary ligament attachment with an anomalous attachment to the meniscofemoral ligament of Wrisberg.[13] Standing anteroposterior radiograph with weight bearing was taken. The measurement method of mechanical axis deviation (MAD) had been referred to Wang et al.[14] The MAD was the distance from the center of the knee joint (CK) to the mechanical axis of the lower limb (HA). And if the CK located inside of HA, the MAD was defined as positive, otherwise the opposite. All the symptomatic knees had undergone computed tomography (CT) scan and the coronal CT scan analysis of patellofemoral joint, which was used to evaluate the relative positional changes between patellar and femoral condylar, including lateral patellofemoral angle (LPFA), PFI, and lateral shift distance (LSD). The positive or negative definition of LSD was same as MAD. Kujala score and Lysholm score were adopted to evaluate clinical function. Meanwhile, McMurray test and Patella grinding test were performed.

2.4. The arthroscopic surgical technique

After standard arthroscopic examination and the DLM tear could be confirmed by arthroscopy simultaneously. Arthroscopic radiofrequency wands were used to perform the DLM plasty. The C-shaped structure of the meniscus should be retained and most of the center meniscal tissue was removed which could make a normal-shaped meniscus. Moreover, the DLM tears should be sutured or repaired when possible. During the operation, the cartilage in the patellofemoral joint and tibiofemoral joint also should be evaluated.

2.5. Evaluation in symptomatic knees at multiple follow-up time

Postoperatively, the symptomatic knees should be evaluated at 2-month, 12-month, and last follow-up time, respectively. The clinical measurement was similar to preoperative evaluation.

2.6. Statistical analysis

Data were analyzed by using SPSS software for Windows (version 21.0; Chicago, IL). Preoperative and postoperative McMurray test and Patella grinding test were analyzed by the Chi-squared test. Wilcoxon signed ranks test was used to pairwise compare the difference of MAD, LPFA, PFI, LSD, Kujala score, and Lysholm score at different follow-up time points and Friedman test was used to 4 multiple-group comparison. Statistical significance was accepted for $P < .05$ in 4 multiple-group comparison and $P < .008$ in pairwise comparison. Patients were grouped by the PFI whether it greater than 1.6 or not. Mann–Whitney test was used to group comparison and Wilcoxon signed ranks test was used to compare the difference between preoperative and the last follow-up. Statistical significance was accepted for $P < .05$.

3. Results

3.1. Demographic analysis

Forty-one patients who underwent arthroscopic DLM plasty were included in this study and the demographic data are listed in Table 1. To exclude trauma-related chondral disease, such as traumatic arthritis, the mean injury to operation interval was 22.3 ± 11.5 days. And the mean last follow-up time was about 24 months (mean, 23.8 months).

Table 1

Demographic characteristics and intraoperative data.

Basic information	Data
Age, mean ± SD, y	26.7 ± 9.2
Sex, male/female, n	18/23
Side, left/right, n	24/17
BMI, mean ± SD, kg/m^2	24.3 ± 1.5
Injury to operation interval, mean ± SD, d	22.3 ± 11.5
Type of injury (sprain or fall, sports injury, traffic accident), n	29/9/3
Last follow-up time, mean, range, mo	23.8, 17–28

BMI = body mass index, SD = standard deviation.

3.2. Physical examination results

It showed significant difference of the physical examination, including McMurray test ($P<.001$) and Patella grinding test ($P=.028$), among 4 multiple-group comparison. Comparing to preoperative McMurray test (92.7%), the postoperative showed significant decline in positive rate at each follow-up time point (12.2%, 4.9%, 0%). However, the positive rate of Patella grinding test increased and there was statistically significant difference between preoperative (19.5%) and last follow-up time point (48.8%) ($P=.005$) (Table 2).

3.3. Imaging index and functional score results

Among the different time point measurement and clinical evaluation, all the change of MAD (−0.7 ± 2.1, −9.4 ± 3.2, −10.0 ± 3.8, −11.4 ± 4.3), LPFA (11.9 ± 5.8, 7.2 ± 4.5, 5.8 ± 3.3, 6.4 ± 3.2), PFI (1.7 ± 0.3, 1.9 ± 0.4, 2.0 ± 0.4, 2.1 ± 0.4), LSD (1.0 ± 4.0, −0.5 ± 3.3, −0.7 ± 3.2, −0.6 ± 2.9), Kujala score (65.9 ± 10.0, 85.2 ± 6.4, 81.6 ± 5.5, 79.4 ± 8.0), and Lysholm score (61.8 ± 10.2, 89.5 ± 5.0, 87.4 ± 4.5, 85.4 ± 3.8) showed significant difference ($P<.001$) (Tables 3 and 4). The clinical evaluation changed with follow-up time (Figs. 1 and 2). Then all the 41 patients were grouped by PFI, patients with PFI > 1.6 compared with those patients with PFI < 1.6. Both 2 groups, the last follow-up MAD (>1.6: −10.8 ± 4.6, <1.6, −12.1 ± 3.8) were significant decrease from the preoperative MAD (>1.6: −0.8 ± 1.7, <1.6: −0.5 ± 2.6) respectively (>1.6: $P<.001$, <1.6: $P<.001$). However, the comparison between group > 1.6 and group < 1.6 showed no statistically significant difference at each time point ($P=.674$, .124, .338, .581). The preoperative LPFA similar to PFI, which also indicated patellar tilt, were 8.4 ± 3.4 in group > 1.6 and 16.4 ± 5.0 in group < 1.6 ($P<.001$). The 2 groups' LSD at last follow-up time point were −1.5 ± 2.6 in group > 1.6 and 0.6 ± 2.8 in group < 1.6. Moreover, only the group > 1.6 showed significant difference between the last follow-up and preoperative measurement ($P<.001$). And no

Table 2

Physical examination before and after surgery.

	Time				
Physical examination	Preoperative	2 mo	12 mo	Last follow-up	P^*
McMurray test (+/−)	38/3	5/36†	2/39†	0/41†	<.001^a
Patella grinding test (+/−)	8/33	12/29	17/24	20/21†	.028^a

Note: McMurray test, preoperative and 2 months, Pearson test $P<.001$; preoperative and 12 months, Pearson test $P<.001$; preoperative and last follow-up, Pearson test $P<.001$; 2 months and 12 months, continuity correction $P=.429$; 2 months and last follow-up, continuity correction $P=.065$; 12 months and last follow-up, continuity correction $P=.474$.

Patella grinding test, preoperative and 2 months, Pearson test $P=.304$; preoperative and 12 months, Pearson test $P=.031$; preoperative and last follow-up, Pearson test $P=.005$; 2 months and 12 months, Pearson test $P=.248$; 2 months and last follow-up, Pearson test $P=.070$; 12 months and last follow-up, Pearson test $P=.506$.

* Chi-squared test, data of R × C table: [a]Pearson test, statistically significant ($P<.05$).

† Chi-squared test, data of 2 × 2 table, significantly different from the preoperative ($P<.008$).

‡ Chi-squared test, data of 2 × 2 table, significantly different from the 2 months ($P<.008$).

§ Chi-squared test, data of 2 × 2 table, significantly different from the 12 months ($P<.008$).

Table 3

Evolution of imaging index before and after surgery.

	Time				
Imaging index	Preoperative, mean ± SD (95% CI)	2 mo, mean ± SD (95% CI)	12 mo, mean ± SD (95% CI)	Last follow-up, mean ± SD (95% CI)	P^*
MAD, mm	−0.7 ± 2.1 (−1.4 to −0.0)	−9.4 ± 3.2† (−10.4 to −8.4)	−10.0 ± 3.8† (−11.2 to −8.8)	−11.4 ± 4.3†,‡,§ (−12.8 to −10.0)	<.001*
LPFA, °	11.9 ± 5.8 (10.1 to 13.7)	7.2 ± 4.5† (5.8 to 8.6)	5.8 ± 3.3† (4.7 to 6.8)	6.4 ± 3.2† (5.4 to 7.4)	<.001*
PFI	1.7 ± 0.3 (1.5 to 1.8)	1.9 ± 0.4† (1.8 to 2.1)	2.0 ± 0.4† (1.9 to 2.2)	2.1 ± 0.4† (1.9 to 2.2)	<.001*
LSD, mm	1.0 ± 4.0 (−0.2 to 2.3)	−0.5 ± 3.3† (−1.5 to 0.5)	−0.7 ± 3.2†,§ (−1.7 to 0.3)	−0.6 ± 2.9† (−1.5 to 0.4)	<.001*

Note: MAD, preoperative and 2 months, $P<.001$; preoperative and 12 months, $P<.001$; preoperative and last follow-up, $P<.001$; 2 months and 12 months, $P=.145$; 2 months and last follow-up, $P=.001$; 12 months and last follow-up, $P=.004$.

LPFA, preoperative and 2 months, $P<.001$; preoperative and 12 months, $P<.001$; preoperative and last follow-up, $P<.001$; 2 months and 12 months, $P=.013$; 2 months and last follow-up, $P=.093$; 12 months and last follow-up, $P=.145$.

PFI, preoperative and 2 months, $P<.001$; preoperative and 12 months, $P<.001$; preoperative and last follow-up, $P<.001$; 2 months and 12 months, $P=.226$; 2 months and last follow-up, $P=.136$; 12 months and last follow-up, $P=.375$.

LSD, Preoperative and 2 months, $P<.001$; Preoperative and 12 months, $P<.001$; Preoperative and Last Follow-up, $P<.001$; 2 months and 12 months, $P=.007$; 2 months and Last Follow-up, $P=.586$; 12 months and Last Follow-up, $P=.573$.

CI = confidence interval, LPFA = lateral patellofemoral angle, LSD = lateral shift distance, MAD = mechanical axis deviation, PFI = patellofemoral index, SD = standard deviation.

* Friedman test, statistically significant ($P<.05$).

† Wilcoxon signed ranks test, significantly different from the preoperative ($P<.008$).

‡ Wilcoxon signed ranks test, significantly different from the 2 months ($P<.008$).

§ Wilcoxon signed ranks test, significantly different from the 12 months ($P<.008$).

Table 4

Evolution of functional score before and after surgery.

Functional score	Time				P^*
	Preoperative, mean ± SD (95% CI)	2 mo, mean ± SD (95% CI)	12 mo, mean ± SD (95% CI)	Last follow-up, mean ± SD (95% CI)	
Kujala	65.9 ± 10.0 (62.7–69.1)	85.2 ± 6.4† (83.1–87.2)	81.6 ± 5.5† (79.9–83.3)	79.4 ± 8.0†,‡ (76.8–81.9)	<.001*
Lysholm	61.8 ± 10.2 (58.6–65.0)	89.5 ± 5.0† (87.9–91.1)	87.4 ± 4.5† (85.9–88.8)	85.4 ± 3.8†,‡ (84.2–86.6)	<.001*

Note: Kujala, preoperative and 2 months, $P<.001$; preoperative and 12 months, $P<.001$; preoperative and last follow-up, $P<.001$; 2 months and 12 months, $P=.018$; 2 months and last follow-up, $P=.003$; 12 months and last follow-up, $P=.058$.

Lysholm, preoperative and 2 months, $P<.001$; preoperative and 12 months, $P<.001$; preoperative and last follow-up, $P<.001$; 2 months and 12 months, $P=.032$; 2 months and last follow-up, $P<.001$; 12 months and last follow-up, $P=.019$.

CI = confidence interval, SD = standard deviation.

* Friedman test, statistically significant ($P<.05$).

† Wilcoxon signed ranks test, significantly different from the preoperative ($P<.008$).

‡ Wilcoxon signed ranks test, significantly different from the 2 months ($P<.008$).

§ Wilcoxon signed ranks test, significantly different from the 12 months ($P<.008$).

significant difference of LSD in group < 1.6 ($P=.267$). But at the 3 postoperative follow-up time points, LSD in group > 1.6 were significant lower than those in group < 1.6 (>1.6: −1.5 ± 2.8, −1.6 ± 2.7, −1.5 ± 2.6; <1.6: 0.8 ± 3.4, 0.4 ± 3.6, 0.6 ± 2.8. $P=.010$, .038, .011). There was significant difference between the last follow-up time and preoperative both of Kujala score (group > 1.6: $P=.001$; group < 1.6: $P<.001$) and Lysholm score (group > 1.6: $P<.001$; group < 1.6: $P<.001$). These difference were not statistically significant at each time point (Kujala: $P=.590$, .654, .571, .833; Lysholm: $P=.385$, .430, .979, .267) (Table 5).

4. Discussion

The most important finding of our present study was that the after arthroscopic plasty for complete type DLM which decreased the thickness and width of the residual meniscus, in turn causing the varus deformity significantly decreased or a valgus inclination developed. Moreover, the consequent changes of patellofemoral joint caused a certain amount of patellar tilt and patellar dislocation, aggravated the lateral patellar compression syndrome.

Several studies have evaluated the clinical outcomes of arthroscopic meniscectomy for symptomatic DLM.[15,16] There

Table 5

Evolution of imaging index and functional score between group PFI > 1.6 and group PFI < 1.6.

Grouped by PFI	Time				Variation	P^*
	Preoperative, mean ± SD	2 mo, mean ± SD	12 mo, mean ± SD	Last follow-up, mean ± SD		
PFI						
>1.6	1.9 ± 0.2	2.1 ± 0.4	2.1 ± 0.4	2.2 ± 0.3	0.4 ± 0.3	.004‡
<1.6	1.3 ± 0.2	1.7 ± 0.3	2.0 ± 0.4	1.9 ± 0.5	0.6 ± 0.4	.001‡
$P^†$	<.001‡	.001‡	.318	.095	.090	
MAD, mm						
>1.6	−0.8 ± 1.7	−8.8 ± 3.3	−9.5 ± 4.3	−10.8 ± 4.6	10.2 ± 4.5	<.001‡
<1.6	−0.5 ± 2.6	−10.1 ± 2.9	−10.6 ± 2.9	−12.1 ± 3.8	11.6 ± 4.1	<.001‡
$P^†$	.674	.124	.338	.581	.528	
LPFA, °						
>1.6	8.4 ± 3.4	5.7 ± 4.0	4.6 ± 2.8	5.5 ± 2.9	3.6 ± 2.3	.002‡
<1.6	16.4 ± 5.0	9.0 ± 4.5	7.3 ± 3.3	7.6 ± 3.2	8.9 ± 4.8	<.001‡
$P^†$	<.001‡	.029‡	.007‡	.050	<.001‡	
LSD, mm						
>1.6	0.8 ± 3.7	−1.5 ± 2.8	−1.6 ± 2.7	−1.5 ± 2.6	2.5 ± 1.8	<.001‡
<1.6	1.3 ± 4.4	0.8 ± 3.4	0.4 ± 3.6	0.6 ± 2.8	2.2 ± 1.2	.267
$P^†$	.563	.010‡	.038‡	.011‡	.655	
Kujala						
>1.6	66.7 ± 11.1	85.3 ± 6.5	80.9 ± 5.0	79.1 ± 7.6	14.1 ± 11.1	.001‡
<1.6	64.9 ± 8.6	85.0 ± 6.5	82.5 ± 6.1	79.7 ± 8.7	15.2 ± 9.5	<.001‡
$P^†$	.590	.654	.571	.833	.617	
Lysholm						
>1.6	63.3 ± 10.1	89.2 ± 5.3	87.3 ± 4.4	85.9 ± 4.1	22.6 ± 10.3	<.001‡
<1.6	59.9 ± 10.3	89.9 ± 4.6	87.4 ± 4.8	84.7 ± 3.3	24.8 ± 10.9	<.001‡
$P^†$	.385	.430	.979	.267	.599	

LPFA = lateral patellofemoral angle, LSD = lateral shift distance, MAD = mechanical axis deviation, PFI = patellofemoral index, SD = standard deviation.

* Wilcoxon signed ranks test, the P-value showed the statistically difference between preoperative and the last follow-up. Variation showed the absolute values of difference between preoperative and the last follow-up.

† Mann–Whitney test, the P-value showed the statistically difference at different time points between PFI > 1.6 and PFI < 1.6.

‡ Statistically significant ($P<.05$).

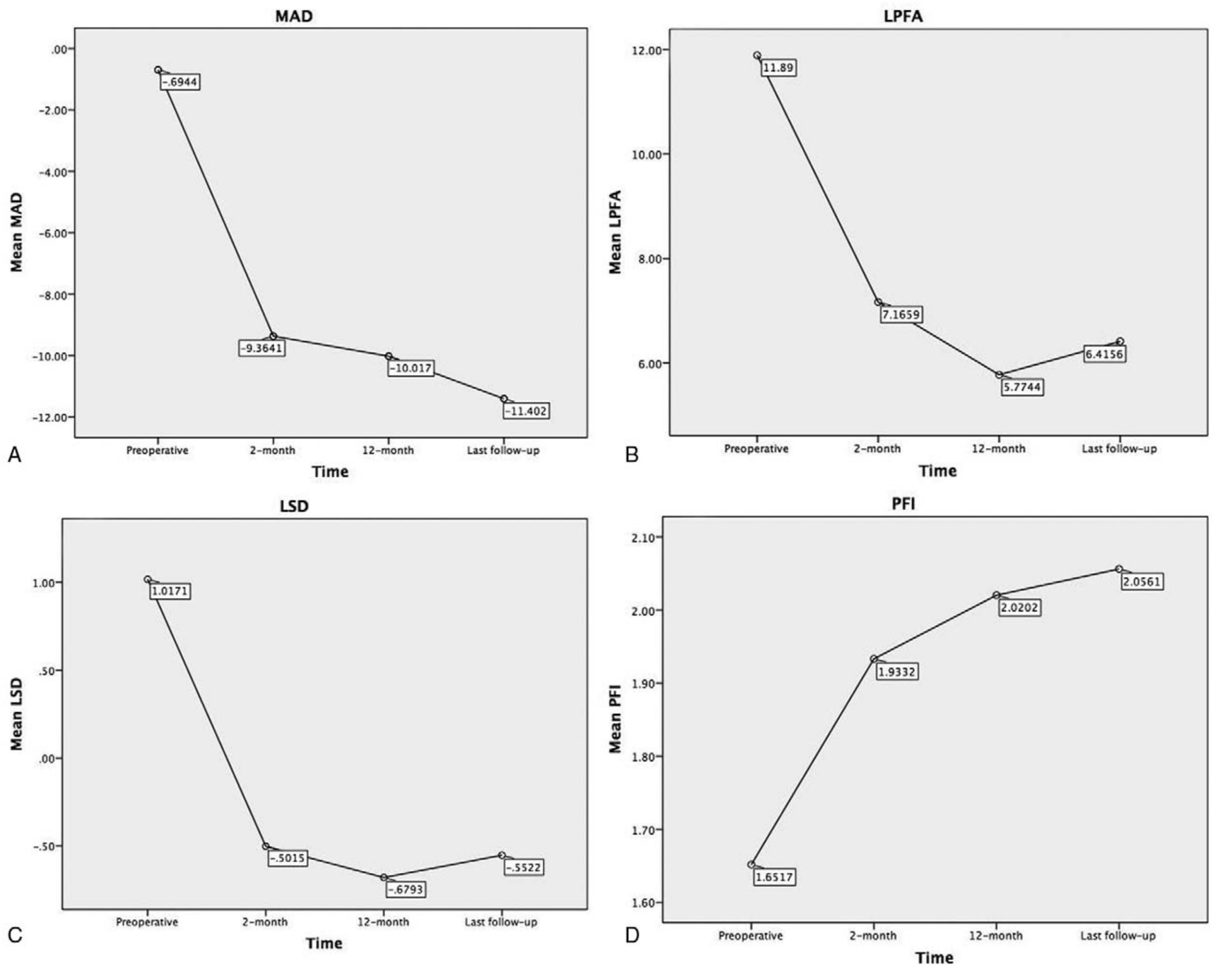

Figure 1. The imaging index changes with the extension of follow-up. (A) MAD, (B) LPFA, (C) PFI, (D) LSD.

have been several studies comparing the evaluation of radiographic and clinical outcomes in cases of DLM plasty and meniscectomy for those normally shaped lateral meniscus tear. Wang et al[14] reported that the axial alignment of the lower limb in adolescents (younger than twenty years of age) with a torn DLM was altered immediately after arthroscopic meniscectomy: the varus deformity was significantly reduced, and a valgus inclination developed in some of these patients. Moreover, the lateral compartment was covered with DLM which affected the contact pressure, also could cause the mechanical balance different from that in knee joints with a semilunar-shaped lateral meniscus. Nawata et al[17] reported that subchondral bone sclerosis or osteoarthritic changes can occur more frequent on the medial compartment in patients with DLM. The possible reason was that the tendency toward varus alignment with DLM could increase the contact pressure on the medial compartment. In our study, we drew a similar conclusion that after the DLM plasty, the axial alignment of lower limb had significant less varus alignment postoperatively (MAD: pre, -0.7 ± 2.1 mm; post, -9.4 ± 3.2 mm; $P < .001$). Furthermore, as it progresses, the MAD decreased gradually which signified the varus alignment increased and it might cause related discomfort, even osteoarthritis progression on lateral compartment (Fig. 1A).

It is well known that the DLM could cause the articular cartilage damage of the lateral compartment.[18] However, to our knowledge, the change of patellofemoral joint in patients with DLM was not clearly defined. Fu et al reported that DLM tear and concomitant articular cartilage lesions in the knee were interrelated and among all the articular cartilage lesions, 44.4% of them were located in patella and trochlea and 42.6% in lateral femoral condyle and lateral tibial plateau. Moreover, 51.9% of lesions in the patella were grade III or IV, 61.9% of lesions in the trochlea were grade III or IV, and grade III or IV lesions accounted for 58.8% of lateral femoral condyle, 34.5% of lateral tibial plateau.[19] Widuchowski et al[20] and Deie et al[21] were, respectively, reported a high incidence of articular cartilage lesions with DLM and they were mostly located in the patella and lateral femoral condyle. In our study, we measured the imaging changes of the patellofemoral joint with DLM by computed tomography (CT) scan. After DLM plasty, LPFA was significant decrease from $11.9 \pm 5.8°$ to $7.2 \pm 4.5°$ ($P < .001$), and PFI was significant increase from 1.7 ± 0.3 to 1.9 ± 0.4 ($P < .001$) (Fig. 1B and C). The change among the 3 follow-up time points showed no statistical difference. Possibly due to the space between femorotibial joint increased, through the knee bore no load during CT scan, the tension force contraction from the ligaments or other soft tissues around knee joint. As a result, the patella was lateral tilted in the cross-section CT scan because the femorotibial gap automatically decrease and lateral aricular capsule slightly tighten which like the lateral compartment of knee was hollowed out. Moreover, the LSD was significant decrease from 1.0 ± 4.0 mm to -0.5 ± 3.3 mm ($P < .001$) which indicated slightly

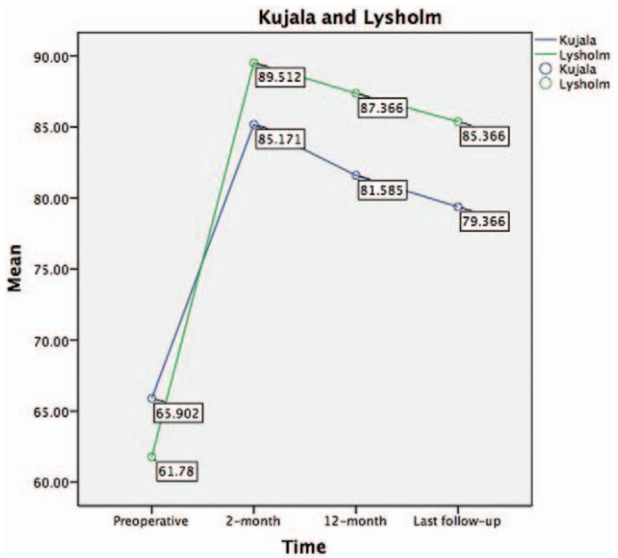

Figure 2. The functional score (Kujala score and Lysholm score) changes with the extension of follow-up.

dislocation of patella (Fig. 1D). Although the change of LPFA, PFI, and LSD among the 3 follow-up time points showed no statistical difference.

The changes of patellofemoral joint lead to symptomatic anterolateral knee pain, especially in the exterior margin pole of patella. Not only that, the vast majority cases' McMurray test got negative after arthroscopy ($P<.001$). However, the positive rate of Patella grinding test showed a slightly increase with the extension of follow-up ($P=.028$). The evaluation at last follow-up time point showed a significant difference with the preoperative examination ($P=.005$). It could be explained by the change of patellofemoral joint which may occur symptomatic lateral patellar compression syndrome. Meanwhile, it might explain why patients with DLM plasty suffer the postoperative anterolateral knee pain. Hu et al[22] reported that a combination of outside-in and FasT-Fix sutures for meniscal plasty had good outcomes which can improve Lysholm score, IKDC score and Tegner score. In our study, the postoperative Kujala score and Lysholm score showed significant increase from preoperative evaluation (K, $P<.001$; L, $P<.001$) which indicated the symptomatic pain caused by meniscus tear had been relieved (Fig. 2). With the extension of follow-up, the symptomatic anterolateral knee pain or the lateral patellar compression syndrome lead to a decrease of functional score. It showed a significant difference between 2-month follow-up time point and last follow-up time point (K, $P=.003$; L, $P<.001$). Especially the Kujala score decreased much more than the Lysholm which might because the change of patellofemoral joint had a worse affection on the knee joint.

In our study, patients were further divided into PFI > 1.6 and PFI < 1.6 which purposed to evaluate those patients with preoperative subluxation or dislocation of the patella. LPFA and PFI were both index of patella tilt and there was significant difference between 2 groups preoperatively, so the postoperative evaluation cannot be statistical analyzed. However, both in 2 groups, Kujala score and Lysholm score showed significant difference between preoperative and the last follow-up. Only group > 1.6 of LSD decreased with statistic difference. Moreover, there was only statistically significant in LSD between 2 groups at the last follow-up time point ($P=.011$). It indicated that there were more possibilities causing patella dislocation in patients with PFI > 1.6 before arthroscopic DLM plasty. Woods et al[23] reported arthroscopic release of the vastus lateralis tendon and lateral patellar retinaculum can improve quadriceps strength and knee function of patients with recurrent patellar dislocation. We strongly suggest that surgeons arthroscopic release of the vastus lateralis tendon and lateral patellar retinaculum for those patients combined with patella dislocation preoperatively. If not, because superposition effect, the patellar tilt might cause more serious symptomatic anterolateral knee pain or the lateral patellar compression syndrome.

4.1. Limitations

We acknowledge that there were some limitations to our study. First, tearing of the DLM may be a risk factor for osteoarthritis, but whether the complete DLM could play a protective role to delay the occurrence of osteoarthritis or not. The limitation for this study did not compare the DLM plasty and arthroscopic meniscus suture surgery. Ding et al reported that asymmetrical shape and long symptomatic duration of DLM were more frequently related to articular cartilage lesions. The presence or absence of a tear in a DLM did not affect articular cartilage lesions.[18] Thus, it might take much longer follow-up time for a sutured DLM to affect the osteoarthritis progression. Second, there was no more appropriate classify index than PFI to group patients. Though PFI of different groups would change after arthroscopic DLM plasty and it might affect the results of other imaging index or functional score. A new grouping index will be needed which could define the degree of patella dislocation and have no interrelation with other evaluation index. Third, lateral retinacular release for those patients who received arthroscopic DLM plasty remained a controversial issue. A separate study on combined arthroscopic DLM plasty and arthroscopic lateral retinacular release will be needed.

5. Conclusion

Arthroscopic DLM plasty can lead to the change of patellofemoral joint and axial alignment of lower limb. It could cause the varus deformity significantly decreased or a valgus inclination developed, and a certain amount of patellar tilt and patellar dislocation, aggravated the symptomatic anterolateral knee pain or the lateral patellar compression syndrome.

6. Author contributions

Conceived the design of the study: JD and HX.
Performed the research: GJ and KK.
Analyzed the data: DX and JZ.
Contributed new methods or models: SG, BC, and YS.
Wrote the paper: JD.
Contributed equally to the study: JD and HX.
Read and approved the content of the final manuscript: All authors.

References

[1] Papadopoulos A, Karathanasis A, KIrkos JM, et al. Epidemiologie, clinical and arthroscopic study of the discoid meniscus variant in Greek population. Knee Surg Sports Traumatol Arthrosc 2009;17:600–6.
[2] Fields LK, Caldwell PEIII. arthroscopic saucerization and repair of discoid lateral meniscal tear. Arthrosc Tech 2015;27:e185–8.

[3] Bae JH, Lim HC, Hwang DH, et al. Incidence of bilateral discoid lateral meniscus in an Asian population: an arthroscopic assessment of contralateral knees. Arthroscopy 2012;28:936–41.
[4] Thorlund JB, Holsgaard-Larsen A, Creaby MW, et al. Changes in knee joint load indices from before to 12 months after arthroscopic partial meniscectomy: a prospective cohort study. Osteoarthritis Cartilage 2016;24:1153–9.
[5] Moulton SG, Bhatia S, Civitarese DM, et al. Surgical techniques and outcomes of repairing meniscal radial tears: a systematic review. Arthroscopy 2016;32:1919–25.
[6] Bellisari G, Samora W, Klingele K. Meniscus tears in children. Sports Med Arthrosc 2011;19:50–5.
[7] Watanabe MT, Takeda S, Ikeuchi H. Atlas of Arthroscopy. Igaku Shoin, Tokyo:1957.
[8] Guettler J, Glisson R, Stubbs A, et al. The triad of varus malalignment, meniscectomy, and chondral damage: a biomechanical explanation for joint degeneration. Orthopedics 2007;30:558–66.
[9] Fairbank TJ. Knee joint changes after meniscectomy. J Bone Joint Surg Br 1948;30:664–70.
[10] Hede A, Larsen E, Sandberg H. Partial versus total meniscectomy. A prospective, randomised study with long-term follow-up. J Bone Joint Surg Br 1992;74:118–21.
[11] Papalia R, Del Buono A, Osti L, et al. Meniscectomy as a risk factor for knee osteoarthritis: a systematic review. Br Med Bull 2011;99:89–106.
[12] Ahn JH, Lee SH, Yoo JC, et al. Arthroscopic partial meniscectomy with repair of the peripheral tear for symptomatic discoid lateral meniscus in children: results of minimum 2 years of follow-up. Arthroscopy 2008;24:888–98.
[13] Ikeuchi H. Arthroscopic treatment of the discoid lateral meniscus. Technique and long-term results. Clin Orthop Relat Res 1982;167:19–28.
[14] Wang J, Xiong J, Xu Z, et al. Short-term effects of discoid lateral meniscectomy on the axial alignment of the lower limb in adolescents. J Bone Joint Surg Am 2015;97:201–7.
[15] Räber DA, Friederich NF, Hefti F. Discoid lateral meniscus in children. Long-term follow-up after total meniscectomy. J Bone Joint Surg Am 1998;80:1579–86.
[16] Aglietti P, Bertini FA, Buzzi R, et al. Arthroscopic meniscectomy for discoid lateral meniscus in children and adolescents: 10-year follow-up. Am J Knee Surg 1999;12:83–7.
[17] Nawata K, Teshima R, Ohno M, et al. Discoid lateral menisci in older patients. A radiographic study of 21 cases. Int Orthop 1999;23:232–5.
[18] Ding J, Zhao J, He Y, et al. Risk factors for articular cartilage lesions in symptomatic discoid lateral meniscus. Arthroscopy 2009;25:1423–6.
[19] Fu D, Guo L, Yang L, et al. Discoid lateral meniscus tears and concomitant articular cartilage lesions in the knee. Arthroscopy 2014;30:311–8.
[20] Widuchowski W, Widuchowski J, Trzaska T. Articular cartilage defects: study of 25,124 knee arthroscopies. Knee 2007;14:177–82.
[21] Deie M, Ochi M, Sumen Y, et al. Relationship between osteochondritis dissecans of the lateral femoral condyle and lateral menisci types. J Pediatr Orthop 2006;26:79–82.
[22] Hu Y, Xu X, Pan X, et al. Combined outside-in and FasT-Fix sutures for the treatment of serious discoid meniscal tears: a midterm follow-up study. Knee 2016;23:1143–7.
[23] Woods GW, Elkousy HA, O'Connor DP. Arthroscopic release of the vastus lateralis tendon for recurrent patellar dislocation. Am J Sports Med 2006;34:824–31.