Long-term Minimum 15-Year Follow-up After Lateral Discoid Meniscus Rim Preservation Surgery in Children and Adolescents

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Background: Discoid meniscus is a congenital variant typically affecting the lateral meniscus of the knee. Historically, surgical intervention when symptomatic consisted of total meniscectomy; however, after degenerative changes were observed, current treatments now focus on rim preservation with arthroscopic saucerization and meniscal repair for instability, when indicated. The purpose of our study was to examine long-term patient-reported outcomes of lateral discoid meniscus (LDM) treated with meniscal-preserving techniques.

Methods: Ninety-eight patients treated arthroscopically for LDM at a single institution at a minimum of 15 years ago were retrospectively identified and contacted by mailers and telephone to participate. Subjective functional outcomes and patient satisfaction data were collected using a questionnaire that included the validated International Knee Documentation Committee Subjective Knee Evaluation Form, Lysholm Score, Marx Activity Rating Scale, Tegner Activity Score, and Western Ontario and McMaster University Osteoarthritis Index Osteoarthritis Index. Patient and surgical characteristics and patient-reported outcomes were summarized by mean and SD, median and interquartile range (interquartile range), or frequency and percent, as appropriate.

Results: Of the 46 patients contacted (response rate of 46/98 eligible), 25 (54%) completed the questionnaires. The mean (±SD) age at initial surgery was 10.8 (± 3.4) and 30.3 (± 3.7) years at final follow-up. The mean (±SD) follow-up time from initial surgery was 19.5 (± 2.8) years (range, 16 to 27). Patient-reported outcomes included: International Knee Documentation Committee

Conclusions: Overall, patient-reported outcomes were favorable at a minimum of 15-year follow-up after rim-preserving saucerization of LDM. While two thirds of patients were satisfied with their surgical outcomes, nearly half of patients underwent revision saucerization with or without meniscal repair. Subsequent long-term follow-up studies with objective outcome measures are important to further elucidate the natural history of LDM and understand how rim-preserving procedures may prevent the development of degenerative processes.

Level of Evidence: Level IV—case series, prognostic study.

Key Words: discoid lateral meniscus, knee, long-term outcomes, meniscal repair, knee arthroscopy, meniscal-preserving

Lateral discoid meniscus (LDM) is a common congenital variant with an estimated prevalence of 1.5% to 3% in the general population. Nonoperative management of LDM is appropriate for asymptomatic or minimally symptomatic cases, but surgical intervention is indicated when symptomatic and impacting physical functionality. Surgical intervention historically entailed total meniscectomy. However, long-term outcomes have demonstrated early degenerative changes in nearly all patients who had undergone total meniscectomy for LDM at 5 and 10 years postoperatively, compared with those who had undergone rim-preserving techniques. Therefore, standard treatment today aims for meniscal-preservation through arthroscopic saucerization (partial meniscectomy) to reshape the meniscus, with meniscal repair when indicated. Short-term clinical, functional, and radiographic outcomes in patients who underwent saucerization have been favorable. Poorer outcomes were associated with increased age, but not correlated with sex, LDM classification, duration of symptoms, or intraoperative presence of meniscal tear.
the original surgery for LDM, there is limited literature on long-term outcomes. As such, the purpose of this study was to assess long-term functional outcomes in children with symptomatic LDM treated by arthroscopic meniscal-preserving saucerization at a minimum follow-up of 15 years. The study hypothesis was that this surgical approach would produce favorable long-term functional outcomes beyond 15-year follow-up, as measured by the following validated instruments: International Knee Documentation Committee (IKDC) form, Lysholm Knee Scoring Scale, Tegner Activity Scale, Marx Activity Rating Scale, and Western Ontario and McMaster University Osteoarthritis Index (WOMAC).

METHODS

Data Source and Patient Selection
After obtaining institutional review board approval for this retrospective study, we searched our single pediatric tertiary care institutional database of operative and medical records and identified a total of 242 unique patients that fit the following inclusion criteria: (1) had at least 1 operative note containing the term “discoid meniscus” before December 31, 2002, (2) age 18 years old or younger at the time of operation. All charts were reviewed to apply the exclusion criteria outlined in Figure 1, resulting in a total of 113 eligible knees in 98 patients. We were able to successfully contact 46/98 patients (47%) through a series of mailings and phone calls; 25/98 patients (26%) completed patient-reported outcome questionnaires. Recruitment contacts were limited to 2 mailings, 3 phone calls, and 3 reminder emails. Because discoid menisci are only managed operatively at the study institution if symptomatic, we could confidently deduce that all identified cases of LDM presented symptomatically. The final cohort included 30 knees in 25 patients with symptomatic LDM managed with rim-preserving saucerization.

After obtaining informed consent, retrospective clinical data were collected from the 25 patients’ electronic medical records, including demographic data, initial clinical assessment, and all documented clinical and operative follow-ups related to LDM management and the related knee(s). Demographic data collected included sex, age at the time of surgery, age at follow-up, and laterality of the affected knee(s). Clinical findings were collected from preoperative records, which were available for 22 knees (73%); the remaining 8 cases initially presented before the study institution’s transition to electronic medical records. Operative reports were reviewed to determine Watanabe type, presence and type of meniscal tear (eg, horizontal, longitudinal), and procedure(s) performed. Follow-up duration was defined as the number of years from the date of surgery to the date on which the patient completed the outcome questionnaires.

Functional Outcome Measures
Subjective functional outcome, interval history, and patient satisfaction data were collected from each patient using a one-time, self-administered, subjective questionnaires regarding the knee(s) that had undergone surgery for LDM. Patients had the option to fill out the questionnaires on paper or through the Research Electronic Data Capture data management platform. Patients completed questionnaires that consisted of patient satisfaction measures, and 5 well-validated functional assessment instruments (Supplemental

FIGURE 1. Cohort inclusion and exclusion flow diagram. N is the number of unique individuals included at each subsequent stage of sample selection. aAs of December 31, 2018. bSuch as rheumatoid arthritis, neuromuscular disorder, developmental delay, or relevant syndromic conditions. LDM indicates lateral discoid meniscus; MDM, medial discoid meniscus.
Materials, Supplemental Digital Content 1, http://links.lww.com/BPO/A405: IKDC Subjective Knee Evaluation Form,14,15 Lysholm Knee Scoring Scale,16 Tegner Activity Scale,17 Marx Activity Rating Scale,14,18 and WOMAC.14,19 The specific WOMAC assessment used in this study summed the values from 3 distinct subscales using the Likert 0 to 4 scale for a maximum score of 96: pain (5 items; range: 0 to 20), stiffness (2 items; range: 0 to 8), and physical function (17 items; range: 0 to 68).

Statistical Analysis
Clinical, surgical, and outcome data are summarized by descriptive statistics. Categorical variables are presented as frequencies with percentages. Normally distributed continuous variables are presented as means (SDs), while non-normal variables are presented as medians [interquartile range (IQR)]. RESULTS

Cohort Characteristics
The final study cohort consisted of 30 knees in 25 patients treated with rim-preserving saucerization by 1 of 6 surgeons. All 22 knees with available preoperative notes were symptomatic: 4 (18%) had pain only, 2 (9%) had mechanical symptoms (eg, locking, grinding, giving way) only, and 16 (73%) had pain and mechanical symptoms. Cohort characteristics and remaining preoperative findings are detailed in Table 1.

Of the 26 knees with documented Watanabe classification, 5 (19%) were type I (stable and complete), 17 (65%) were type II (stable and incomplete), and 4 (15%) were type III (unstable and incomplete). Twenty of the 30 knees (67%) demonstrated lateral meniscal tears at the time of surgery. Eight of the 30 knees (27%) demonstrated lateral meniscal instability upon intraoperative probing. All 30 knees underwent saucerization, 10 (33%) of which underwent meniscal repair (the 8 knees with lateral meniscal instability and 2 additional stable knees with identified tears). Concurrent procedures included synovectomy or lysis of adhesions (3 knees; 10%), cartilage repair with microfracture or drilling (2 knees; 7%), and lateral release (1 knee; 3%). Intraoperative findings are further detailed in Table 2.

Patient-reported Outcomes
Complete patient-reported outcomes are presented in Table 3. The mean (±SD) IKDC score was 77.4 (±17.2), with a median (IQR) reported knee function at follow-up of 9 (IQR, 7 to 10)—a score of 10 indicates no limitations to daily activities. The mean Lysholm score was 78.6 (±21). The median Tegner and Marx scores were 7 (IQR, 6 to 9) and 8 (IQR, 4 to 11), respectively. A Tegner score of 7 corresponds to high-intensity competitive or recreational sports, such as soccer, field hockey, squash, and running. A Marx rating assesses whether an individual runs 2 to 3 times per week and performs activities that require cutting, decelerating, and pivoting at least 1 time per week.14,18 Stratification of Lysholm scores by degree of knee functionality demonstrated 28% excellent (scores 95 to 100), 20% good (scores 84 to 94), 28% fair (scores 65 to 83), and 24% poor (scores ≤ 64). The mean WOMAC score was 7.6 (±11.3) of a maximum of 96.

Seventeen of the 25 patients (68%) reported satisfaction with their surgical outcome. Detailed post-operative outcomes stratified by discoid type and surgical procedure are described in Table 4. Eleven patients (44%) underwent at least 1 subsequent surgical procedure on the ipsilateral knee(s). No patient underwent total knee replacement. Twelve of the 20

### TABLE 1. Cohort Characteristics*

| Patient characteristics (N = 25 patients) | Sex (% male) | 8 (32) |
|-----------------------------------------|-------------|--------|
| Age at surgery (mean ± SD (range)) (y) | 10.8 ± 3.4 (6-18) |
| Age at follow-up (mean ± SD (range)) (y) | 30.3 ± 3.7 (23-36) |
| Time since surgery follow-up (mean ± SD (range)) (y) | 19.5 ± 2.8 (16-27) |
| Laterality | Left | 11 (44) |
| | Right | 9 (36) |
| | Bilateral | 5 (20) |
| Preoperative findings (N = 22 knees) | History of trauma | 3 (14) |
| | Symptoms | 22 (100) |
| | Pain | 20 (91) |
| | Mechanical (locking, grinding, giving way) | 14 (64) |
| Physical examination findings | Joint line tenderness | 16 (73) |
| | Clicking | 5 (23) |
| | Effusion | 7 (32) |
| | McMurray test (positive) | 5 (23) |

*Data are presented as n (%), unless indicated otherwise.
†Follow-up duration was defined as the number of years from the date of surgery to the date upon which the patient-reported outcome questionnaires were completed.

### TABLE 2. Operative Findings and Procedures (N = 30 Knees)*

| Intraoperative findings | Watanabe classification (n = 26) | 1 (stable and complete discoid meniscus) | 5 (19) |
| | II (stable and partial discoid meniscus) | 17 (65) |
| | III (unstable discoid meniscus) | 4 (15) |
| | Meniscal instability (upon probing) | 8 (27) |
| | Meniscal tear (lateral) | 20 (67) |
| | Tear type | Horizontal cleavage | 10 (33) |
| | | Longitudinal | 2 (7) |
| | | Radial | 2 (7) |
| | | Flap | 1 (3) |
| | | Bucket handle | 0 |
| | | Root | 0 |
| | | Other/unspecified | 8 (27) |

| Operative procedures (N = 30 knees) | Operative procedures (discoid) | Scauierization only | 20 (67) |
| | Scauerization and meniscal repair | 10 (33) |
| | Concomitant procedures (nondiscoid) | Synovectomy or lysis of adhesions | 3 (10) |
| | | Plica excision | 2 (7) |
| | | Carilage repair (microfracture, drilling) | 2 (7) |
| | | Lateral release | 1 (3) |

*Data are presented as n (%).
patients (60%) that had undergone operative management for unilateral LDM were later diagnosed with contralateral LDM. Magnetic resonance imaging confirmed contralateral LDM in 10 of those 12 patients (83%); 9 (75%) underwent subsequent surgical management.

**DISCUSSION**

This study demonstrated overall favorable outcomes in children and adolescents with symptomatic LDM treated by arthroscopic meniscal-preserving saucerization at a mean follow-up of nearly 20 years (range, 16 to 27 y), with two thirds of patients reporting satisfaction with their surgical outcomes and no patients requiring total meniscectomy or total knee replacement. Patients were able to maintain a high level of physical activity overtime, considering the high baseline preoperative Tegner scores and high postoperative Marx scores at long-term follow-up. The low WOMAC scores are reassuring against the long-term development of degenerative disease following meniscal-preserving techniques, as has been reported previously at 5- and 10-year follow-up following saucerization with or without meniscal repair.4,5

These favorable patient-reported outcomes are consistent with those of previous studies at short-term and intermediate-term follow-up after arthroscopic saucerization for LDM.6,12,20,21 In fact, long-term outcomes following rim-preserving techniques for symptomatic LDM treatment have often been more favorable than outcome scores (eg, IKDC) reported after other pediatric knee surgeries, including non-LDM indicated knee arthroscopy, ligament repair, or knee replacement.22 For instance, the median Marx score 10 years after arthroscopic anterior cruciate ligament reconstruction was lower than that seen nearly 20 years after arthroscopic saucerization for LDM (6/16 vs. 8/16, respectively).23

This study provides further evidence to support the use of meniscal-preserving surgical techniques for the treatment of symptomatic LDM in children and adolescents to avoid the known deleterious effects of total meniscectomy on long-term knee function.24 Younger patients’ knees are better candidates for such procedures than adults given their increased vascularity and enhanced healing potential.24

However, outcomes were variable, with roughly half of the patients in the present study reporting Lysholm scores in the fair or poor categories at long-term follow-up; the other half of the study population scored in the excellent or good categories. This suggests that there may be various patient and pathology-related factors that play a role in determining long-term functional outcomes. In comparing clinical outcomes at both 2 and 11-year follow-up, Haskel et al25 demonstrated a decline in patient-reported outcomes overtime. At 2 years, only 3 of 27 cases (11%) experienced persistent knee pain, and 4 experienced mechanical symptoms; no cases reported any limitation in physical activities.6 At 11 years, the same patient population demonstrated

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**TABLE 4.** Postoperative Outcomes by Discoid Type and Surgery (N = 26)*

| Discoid Type† | Index Surgery | Meniscal Repair/Revision | Osteoarthritis | Satisfied‡ |
|---------------|---------------|--------------------------|----------------|-----------|
| Type I (n = 5) | S only§       | 1 (25)                   | —              | 4 (100)   |
|               | S+MR¶        | 0                        | 1 (6)          | 7 (58)    |
| Type II (n = 17) | S only|| | 1 (20) | 1 (20) | 5 (100) |
| Type III (n = 4) | S only       | 3 (75)                   | 1 (25)         | 2 (50)    |
|               | S+MR†        | 4 (100)                  |                |           |

*Data are presented as n (%). Discoid type was not documented for 4/30 knees (13%).
†Based on Watanabe classification.
‡At the time of questionnaire completion. Denominator is the number of knees having undergone S or S+MR operation within each discoid type (ie, the n value in the “Index Surgery” column in the same row).
§And cartilage microfracture and drilling (n = 1).
||And plica excision (n = 1), lysis of adhesions/synovectomy (n = 1).
¶And lysis of adhesions (n = 1).
†MR indicates meniscal repair; S, saucerization.
increased rates of knee pain, mechanical symptoms, and functional outcomes, with roughly 40% of the patients reporting fair or poor Lysholm scores.\(^2^5\)

While juxtaposing distinct pediatric study populations has inherent limitations, an approximate comparison of functional outcomes at 20-year follow-up in the present study to outcomes at 11-year follow-up in the Haskel et al\(^2^5\) study support the variable decline in functional outcomes overtime following arthroscopic meniscal-preserving surgery for LDM. In addition to lower IKDC and Lysholm scores, a higher percentage of patients required additional surgical procedures on the affected knee at 20-year follow-up compared with 11-year follow-up (44% to 37%, respectively). Lee et al\(^2^1\) reported a reoperation rate of 33% for LDM on the ipsilateral knee in patients assessed 10 years postoperatively after arthroscopic saucerization. Patient-related and pathology-related variables may impact the rates of gradual functional decline overtime. Yoo et al\(^2^6\) demonstrated an association between lower Lysholm score and reoperation for ipsilateral LDM, as well as age older than 10 years at the time of initial surgery. The latter may partially explain the overall lower Lysholm scores in our cohort with a mean age of 10.8 years at time of surgery. Large, observational studies are necessary to further investigate potential predictors of long-term knee function following arthroscopic meniscal-preserving procedures.

**Limitations**

Despite the relative strengths of this study in its long-term follow-up and use of several well-validated patient-reported outcome measures, the findings of this study must be considered in the context of several limitations. First, the retrospective study design compromises a degree of external validity by impairing the ability to collect a comprehensive set of data. As such, there was a dearth of objective clinical and radiographic findings, which would have been valuable in assessing objective measures of long-term knee pathologies (eg, arthritic changes)\(^2^7\); results were limited to subjective patient satisfaction and functional assessment instruments. Second, varying interpretations of clinical and operative documentation from before 2002 likely introduced measurement bias, which could have skewed results in either direction. Third, recall bias must be considered given the retrospective completion of relatively complex questionnaires by adults who were preadolescents or adolescents at the time of index surgery. Fourth, the nonrandomized recruitment and the response rate of <50% resulted in a small cohort with a large proportion of patients having undergone isolated saucerization treatment without instability or repair. This composition may reflect self-selection, which would introduce selection bias and likely skew results more favorably. As such, comparison of cohorts is limited by the variability in discoid type, meniscal morphology, and surgeon approach and management in other studies. While arthroscopic meniscal-preserving procedures continue to be preferred to total meniscectomy, without a control group and a prospective, observational and/or randomized studies, it is difficult to truly know the natural history of patients with LDM, the various predictors of outcomes long-term, and whether surgery helps to prevent degenerative joint disease.

**CONCLUSIONS**

Overall, patient-reported outcomes were favorable at a minimum of 15-year follow-up after rim-preserving saucerization of LDM. While two thirds of patients were satisfied with their surgical outcomes, nearly half of patients underwent revision saucerization with or without meniscal repair. Subsequent long-term follow-up studies with objective outcome measures are important to further elucidate the natural history of LDM and understand how rim-preserving procedures may prevent the development of degenerative processes.

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