Risk Factors for the Development of a Symptomatic Contralateral Discoid Lateral Meniscus

Jason Nielson, MD; Sean Davis, MD; Aaron Gray, MD, PhD; Brock Wentz, MD; Ikenna Obilor, BSc

School of Medicine, University of Nevada, Las Vegas, Nevada

Corresponding Author Sean Davis, MD. 1701 W. Charleston Blvd, Las Vegas, NV 89102 (email: sean.davis@unlv.edu).

Funding The authors received no financial support for the research, authorship, and publication of this article.

Conflict of Interest The authors report no conflicts of interest.

Acknowledgements We would like to thank Gayle Allenback, our Research Coordinator, for assisting with organization and submission.

ABSTRACT

Background: Discoid menisci (DM) are oval or disc-shaped menisci, differing from the normal crescent shaped meniscus. This difference in shape may be one factor as to why DM are more prone to injury when compared to normal menisci. The purpose of this study was to evaluate potential risk factors that may lead to the development of symptoms, requiring arthroscopic saucerization in adolescents with a history of symptomatic DM in the contralateral extremity.

Methods: We retrospectively reviewed 126 patients with an arthroscopic diagnosis of DM to evaluate for the presence of a symptomatic contralateral DM variant. Mildly symptomatic DM status was identified by patient need for operative intervention, including a pain or popping sensation of the knee. We performed statistical analysis to identify potential risk factors predisposing patients to the development of symptomatic DM in the contralateral extremity, ultimately requiring operative intervention.

Results: Of the 126 patients identified with lateral DM, 21 patients had a subsequent symptomatic contralateral DM that required operative intervention, while the remaining 105 patients may have had an asymptomatic DM variant of the contralateral knee. Patients who actively participated in sports, particularly basketball, and patients less than 10.8 years old were at higher risk for developing symptomatic contralateral DM requiring operative intervention.

Conclusions: Younger patients participating in athletics presenting with symptomatic lateral DM are at increased risk of developing symptoms requiring operative intervention in the contralateral knee.

Keywords: Discoid Lateral Meniscus, Contralateral, Symptomatic, Knee, Adolescent, Arthroscopy

INTRODUCTION

Discoid meniscus (DM) is a common congenital anatomic variation found in children and was first described by Young et al[1] in 1889. In the literature, the reported incidence of DM varies from 0.4% to 17.0%, but it ultimately depends on the specific population being studied and discoid laterality involvement.[2] Smillie et al[3] performed the largest study of DM incidence of nearly 10,000 meniscectomy patients and reported an incidence of 4.7%. Several smaller studies have supported the findings of Smillie et al, reporting values between 3.5% to 5.0%.[4-6] However, incidences are likely underreported owing to most discoid variants having no symptoms. Resultantly, the reported value for the incidence of DM can be more reliably interpreted using the incidence of symptomatic discoid variants.

Similar dilemmas arise when determining bilateral DM incidence, with a reported incidence rate of approximately 20.0%.[7-9] Previous studies mainly include surgical patients and do not reflect the true incidence of bilateral DM. Recent publications have suggested that bilateral discoid variants are more common than previously reported. Connolly et al[10] reported bilateral DM in 9 of 10 patients who underwent bilateral imaging, substantiated by 11 out of 33 (33.0%) cases of lateral DM with tears.[10] In a Japanese cadaveric study, menisci of the same shape were found in the bilateral knees of 253 of 279 (91.0%) cadavers.[11] Therefore, identifying unilateral, symptomatic DM increases the incidence of asymptomatic DM in the contralateral knee. Ahn et al[9] and Bae et al[11] reported that magnetic resonance imaging and arthroscopic evaluation reveals bilateral DM rates as high as 79.0% to 97.0% in patients presenting with unilateral, symptomatic lateral DM.

In this study, we aimed to identify any risk factors that may predispose patients who underwent operative intervention for a symptomatic DM to symptomatic progression of DM of the contralateral knee.

METHODS

Data Gathered

After obtaining exemption status from our Institutional Review Board, we reviewed medical records, radiographic studies, operative reports, and arthroscopic images of 126 patients. All patients were treated arthroscopically for symptomatic DM of the initial knee at presentation by a single surgeon between 2006 and 2017. Data collected included sex, age at the time of surgery, participation in sports, sport type, the need for operative intervention for the contralateral knee, and follow-up length. DM morphology was recorded, including if a meniscal tear was present and whether the lesion was complete, incomplete, or Wrisberg type.

Procedures

DM morphology and stability of the ipsilateral knee were determined during operative intervention under direct visualization and probing. Arthroscopic saucerization of the ipsilateral knee was performed with standard arthroscopic shavers and biters to restore the normal shape of the meniscus. In the presence of meniscal tears, a meniscectomy was performed until the meniscus was deemed to be stable based on arthroscopic probing. Repairs were performed when standard meniscal repair indications were met.

Statistical Methods

We calculated descriptive statistics, including frequencies, means, and standard deviations for the total population and subgroups using Excel (Microsoft; Redmond, WA). Comparison groups were unilateral DM injury and bilateral DM injury. Univariate comparison between groups was performed using student *t*-tests and Fisher's exact tests when appropriate. Multivariate logistic regression was performed for independent variables, which predicted the binary outcome of unilateral or bilateral DM injury using SAS 9.4 (SAS; Cary, NC). An efficient multivariate model was selected based on forward selection methods while controlling for demographic variables. Significance level was set at $P < 0.05$ with no adjustment for multiple testing.

RESULTS

We reviewed a total of 126 cases of patients with symptomatic DM undergoing arthroscopic debridement or saucerization. Demographic data for the entire population is presented in Table 1. Mean age was 12.6 years (standard deviation = 3.39). Approximately 125 (99.2%) of the study population underwent saucerization at the time of debridement or received both debridement and repair.

Risk Factor Rates

Among the population, 21 patients (16.7%) subsequently presented for contralateral knee pain and were eventually diagnosed with a contralateral, symptomatic DM (bilateral grouping). Comparison of population differences between patients with unilateral or bilateral injury can be seen in Table 2. Upon initial presentation, patients with bilateral discoid injury were on average younger than those presenting with only single-sided symptoms (10.8 years vs 12.9 years, respectively, $P = 0.008$). Additionally, there was a higher frequency of overall sports participation for those with bilateral involvement (Table 3, $P = 0.001$). All patients with bilateral involvement participated in sports; however, when compared by specific sport, bilateral cases were only found to be significantly associated with basketball participation (Table 3, $P = 0.038$). No differences were found between populations regarding sex, type of discoid, presence of a discoid tear or lateral femoral condyle osteochondritis dissecans lesion, or operative procedures performed.

Univariate logistic regression was performed on all independent variables predicting the binary outcomes of unilateral versus bilateral involvement (Table 4). Sport (as a binary variable) and saucerization were excluded from the analysis because they had a 100.0% frequency and correlation among bilateral cases, which prevented the logistic regression from convergence

Table 1. *Population Demographic and Independent Variable Data*

Variable	n (%), n = 126
Age, mean (SD)[a]	12.6 (3.39)
Sex	
Male	50 (39.7%)
Female	76 (60.3%)
Discoid Type	
Unknown	3 (2.4%)
I	55 (43.7%)
II	56 (44.4%)
III	12 (9.5%)
Torn Discoid	69 (54.8%)
Saucerization	125 (99.2%)
Repair needed	57 (45.2%)
Re-operation	80 (63.5%)
Associated LFC OCD	4 (3.2%)
Sport Participation	
Basketball	17 (13.5%)
Soccer	28 (22.2%)
Football	16 (12.7%)
Gymnastics/Cheer/Dance	16 (12.7%)
Other	14 (11.1%)
No Sport	35 (27.8%)
Bilateral Discoid	21 (16.7%)

SD, Standard Deviation; LFC OCD, lateral femoral condyle osteochondritis dissecans

[a]Values for age reported as mean and standard deviation. All other values are reported as frequencies with percentages in parentheses.

Table 2. *Comparison of Unilateral and Bilateral Discoid Meniscus*

Variable	Unilateral n (%) n = 105	Bilateral n (%) n = 21	*P*-Value[a]
Age, mean (SD)[b]	12.9 (3.4)	10.8 (2.8)	0.008
Sex			
Male	44 (41.9)	6 (28.6)	0.331
Female	61 (58.1)	15 (71.4)	
Discoid Type			
Unknown	3 (2.9)	0 (0)	0.345
I	49 (46.7)	6 (28.6)	
II	43 (41.0)	13 (61.9)	
III	10 (9.5)	2 (9.5)	
Torn Discoid	55 (52.4)	14 (66.7)	0.337
Saucerization	104 (99.0)	21 (100)	1.000
Repair needed	48 (45.7)	9 (42.9)	1.000
Re-operation	68 (64.8)	12 (57.1)	0.621
Associated LFC OCD	2 (1.9)	2 (9.5)	0.129
Sport Participation			
Basketball	11 (10.5)	6 (28.6)	0.002
Soccer	24 (22.9)	4 (19.0)	
Football	13 (12.4)	3 (14.3)	
Gymnastics/Cheer/Dance	11 (10.5)	5 (23.8)	
Other	11 (10.5)	3 (14.3)	
No Sport	35 (33.3)	0 (0)	

SD, standard deviation; LFC OCD, lateral femoral condyle osteochondritis dissecans
[a]Significant values (*P*<0.05) bolded. Fisher's exact test was used for comparison of categorical variables.
[b]Student's t-test was used for comparison of means
Watanabe Classification was used for discoid type
The majority of patients had unilateral meniscal involvement, with type Watanabe Type I variants comprising the majority of repairs

Table 3. *Comparison of Sport Type by Discoid Laterality*

Sport	Unilateral n (%) n = 105	Bilateral n (%) n = 21	*P*-value[a]
Basketball	11 (10.5)	6 (28.6)	**0.038**
Soccer	24 (22.9)	4 (19.0)	1.000
Football	13 (12.4)	3 (14.3)	0.730
Gymnastics/Cheer/Dance	11 (10.5)	5 (23.8)	0.143
Other	11 (10.5)	3 (14.3)	0.703
Any Sport	70 (66.7)	21 (100)	**0.001**

[a]Significant values (*P*<0.05) bolded. Fisher's exact test was used for comparison of categorical variables

Table 4. *Univariate Logistic Models predicting Bilateral Discoid Meniscus Injury*

Variable	OR	Lower 95.0%	Upper 95.0%	R-Square	*P*-Value[a]
Age	0.83	0.72	0.96	0.088	0.011
Gender	1.73	0.62	4.83	0.016	0.292
Torn Discoid	1.82	0.68	4.87	0.020	0.234
Repair	0.89	0.35	2.29	0.001	0.810
Re-operation	0.73	0.28	1.88	0.006	0.508
LFC OCD	5.42	0.72	40.88	0.033	0.101
Sport Type					
Basketball	3.42	1.10	10.63	0.054	0.034
Soccer	0.79	0.24	2.59	0.002	0.702
Football	1.18	0.31	4.56	0.001	0.811
Gymnastics	2.67	0.82	8.71	0.032	0.104
Other	1.29	0.33	5.04	0.002	0.713

OR, odd ratios; LFC OCD, lateral femoral condyle osteochondritis dissecans
[a]Bolded values statistically significant, *P*<0.05

Table 5. *Efficient Multivariate Logistic Model Predicting Bilateral Discoid Meniscus Injury*

Variable	OR	Lower 95.0%	Upper 95.0%	*P*-value[a]
Age	0.83	0.72	0.96	0.012
Gender	1.41	0.48	4.19	0.532
Basketball	3.36	1.01	11.19	0.048

OR, odds ratios
[a]Bolded values statistically significant, P<0.05. Gender included for control purposes. R-square value for the entire model is 0.145.

and produced unrealistic odds ratios (ORs). As such, we have included each sport as a separate binary variable. Only two independent variables significantly predicted cases with bilateral involvement, age, and basketball participation. Age was treated as a continuous variable. For each 1-year increase in age at initial presentation of the ipsilateral knee, there was approximately a 17.0% decrease in the odds of having a contralateral or bilateral discoid injury (OR = 0.83, 95.0% confidence interval (CI) 0.72-0.96, *P* = 0.011). Patients that participated in basketball were 3.4 times more likely to have a bilateral discoid injury (OR = 3.42, 95.0% CI 1.10-10.63, *P* = 0.034).

A multivariate logistic model was created by forward selection means. For control purposes, predictive variables included in the final model were age (*P* = 0.012), basketball participation (*P* = 0.048), and gender (*P* = 0.53)(Table 5). ORs among the variables were similar to their univariate counterparts. The final model presented in Table 5 yielded an adjusted $r^2 = 0.15$.

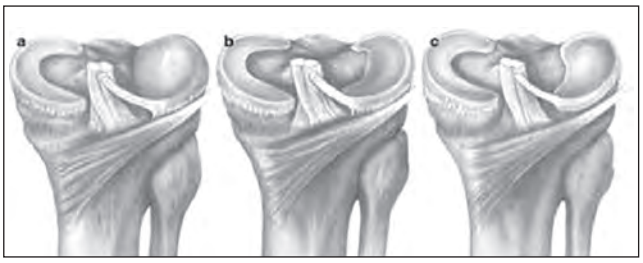

Figure 1. *Illustration of the Watanabe classification.[16] A) Type 1: Complete, disc-shaped meniscus completely covering the lateral tibial plateau with normal posterior attachment. B) Type 2: Incomplete, semilunar shape with normal posterior attachment covering less than 80.0% of the lateral tibial plateau. C) Type 3: Wrisberg type resembling a normal meniscal shape but lacking posterior meniscal attachments (coronary ligament). The Wrisberg ligament connects the posterior horn of the lateral meniscus.*

DISCUSSION

The current recommendation for treatment of symptomatic DM is conservative management, including rest, physical therapy, nonsteroidal anti-inflammatory drugs, activity modification, and observation for possible transition of asymptomatic into symptomatic DM in the contralateral knee. Operative intervention with arthroscopic saucerization is only considered in cases of persistently symptomatic menisci or the presence of a meniscal tear. Classic symptoms of DM include pain, popping, snapping, and decreased knee extension.[7,12] Historically, treatment for DM was a total meniscectomy.[7,8] More recently, there have been vast improvements in arthroscopic surgical techniques, and the importance of meniscus preservation has become evident, resulting in meniscus-sparing procedures becoming the gold standard. Complete meniscectomies are avoided because of the high rate of osteoarthritic changes seen at long-term follow-up.[11,13-15] These changes are due to the impaired ability of the meniscus to transmit loads and stabilize the knee joint.

Of the multiple classification systems of lateral DM proposed, the Watanabe system (Figure 1)[16] is the most common and widely used.[6] Watanabe described three major DM variants: 1) complete, disc-shaped meniscus covering the tibial plateau; 2) incomplete, semilunar-shaped meniscus with partial tibial plateau coverage; and 3) Wrisberg-type, hypermobile meniscus resulting from deficient posterior meniscotibial attachments. Both the incomplete and Wrisberg types have been associated with higher risks of meniscal tears, typically resulting in complex tear patterns that lead to large meniscal resections, commonly requiring subtotal or total meniscectomies to achieve stability.[18] Several studies have theorized why DM are more prone to tearing. One theory is that DM is thicker with poorer vascularity than normal menisci.[15,17] In Wrisberg types, the decreased peripheral attachments lead to increased mobility and a higher incidence of tearing. Evidence also suggests that the compositional arrangement of DM itself can be predisposed to meniscus tearing, owing to the number and orientation of collagen fibers that differ from normal menisci. Normally, menisci contain inner circular fibers that allow for the dissipation of hoop stresses during weight bearing and peripheral radial fibers, typically completed in two functions. The first function is to protect circular fibers from tearing, and the second function is to serve as an anchor to the joint capsule. The fibers of DM are disorganized and smaller in number, resembling the characteristics in a degenerating meniscus, resulting in the decreased meniscal ability to dissipate hoop stresses during weight bearing.[19] Decreases in collagen concentration and an inability to effectively dissipate hoop stresses predispose the DM to tears.[19,20] Rohren et al[21] found that the incidence of tears in DM is significantly higher when compared to those with normal semilunar meniscus (71.0% vs 54.0%, respectively). Other studies have shown an increase in the incidence of either lateral or medial DM tears, ranging between 38.0% and 88.0%.[3,13,21-24]

Bilateral DM have a reported incidence ranging from 5.0% to 20.0%.[6,17,25-27] However, these studies reported incidence based on patients that developed symptoms requiring operative intervention in opposite knees after the affected knees had already been treated. Of these, between 54.0% to 84.0% were operated on, secondary to the torn menisci in the contralateral knee.[13,21-23] In our series, the incidence of symptomatic bilateral DM was 16.0% (21 of 126 patients) among patients treated by arthroscopic saucerization with or without a meniscal repair. Of these, all 21 patients participated in sports. Approximately 14 (66.7%) developed symptoms secondary to a meniscal tear in the contralateral knee. We identified several characteristics that lead to an increased risk of developing a symptomatic contralateral DM. Patients younger than 11 years old and patients active in athletics, especially those participating in basketball, resulted in a higher risk for developing a symptomatic contralateral DM that required operative intervention. Although statistically significant, basketball participation does not appear to demonstrate clinical relevance. Two-thirds (66.0%) of the time, symptoms began as a result of a contralateral DM tear. In the presence of a tear, the saucerization and resection plane is determined by the tear pattern and the stability of the remaining tissue, typically resulting in larger meniscectomies. In contrast, during saucerization for DM in which there is no tear present, the operating surgeon could resect only what was necessary to resemble a normal semilunar meniscus. This technique will result in a much smaller meniscectomy mimicking the shape and stability seen in a normal semilunar meniscus. We hypothesize that earlier and more aggressive strategies in the diagnosis and treatment of young, active patients may afford the treating surgeons more control over the

meniscal resection. Comparative studies of different treatment strategies for DM that access clinical differences may be a possible area of future research.

In conclusion, the presence of symptomatic DM in the ipsilateral knee increases the risk of the development of future symptomatic DM in the contralateral knee. Several factors increase the risk of development of DM in the contralateral knee, including younger age, participation in sports (particularly basketball), and bilateral discoid injury. Identification of these risk factors will allow clinicians to better identify asymptomatic DM of the contralateral knee before symptomatic progression. Further studies, such as comparing treatment strategies for DM, are required to address treatment options once an asymptomatic DM of the contralateral knee is identified.

REFERENCES

1. Young RB. The external semilunar cartilage as a complete disc. In: Cleland J, Mackay JY, Young RB, eds. Memoirs and memoranda in anatomy. London, UK: Williams and Norgate; 1889.
2. Yaniv M, Blumberg N. The discoid meniscus. J Child Orthop. 2007;1(2):89-96. doi: 10.1007/s11832-007-0029-1.
3. Smillie IS. Injuries to the knee joint. 4th ed. Edinburgh, UK: Churchill Livingstone; 1970.
4. Noble J. Lesions of the menisci. Autopsy incidence in adults less than fifty-five years old. J Bone Joint Surg Am. 1977;59(4):480-483.
5. Casscells SW. Gross pathological changes in the knee joint of the aged individual: a study of 300 cases. Clin Orthop Relat Res. 1978;(132):225-232.
6. Dickhaut SC, DeLee JC. The discoid lateral-meniscus syndrome. J Bone Joint Surg Am. 1982;64(7):1068-1073.
7. Kelly BT, Green DW. Discoid lateral meniscus in children. Curr Opin Pediatr. 2002;14(1):54-61. doi: 10.1097/00008480-200202000-00010.
8. Fleissner PR, Eilert RE. Discoid lateral meniscus. Am J Knee Surg. 1999;12(2):125-131.
9. Ahn JH, Lee SH, Yoo JC, et al. Bilateral discoid lateral meniscus in knees: evaluation of the contralateral knee in patients with symptomatic discoid lateral meniscus. Arthroscopy. 2010;26(10):1348-1356. doi: 10.1016/j.arthro.2010.02.008.
10. Connolly B, Babyn PS, Wright JG, Thorner PS. Discoid meniscus in children: magnetic resonance imaging characteristics. Can Assoc Radiol J. 1996 Oct;47(5):347-54. PMID: 8857969.
11. 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(7):936-941. doi: 10.1016/j.arthro.2011.12.003.
12. Chen YC. Arthroscopic meniscectomy of the discoid meniscus. Presented at: American Association of Nurse Anesthetists Annual Meeting; March 1988; Washington, DC.
13. Bin SI, Kim JC, Kim JM, et al. Correlation between type of discoid lateral menisci and tear pattern. Knee Surg Sports Traumatol Arthrosc. 2002;10(4):218-222. doi: 10.1007/s00167-001-0273-8.
14. 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(11):1579-1586. doi: 10.2106/00004623-199811000-00003.
15. Zaman M, Leonard MA. Meniscectomy in children: results in 59 knees. Injury. 1981;12(5):425-428. doi: 10.1016/0020-1383(81)90016-4.
16. Kim JG, Han SW, Lee DH. Diagnosis and treatment of discoid meniscus. Knee Surg Relat Res. 2016; 28(4):255-262. doi: 10.5792/ksrr.16.050.
17. Ikeuchi H. Arthroscopic treatment of the discoid lateral meniscus: technique and long-term results. Clin Orthop Relat Res. 1982;(167):19-28.
18. Atay OA, Doral MN, Leblebicioğlu G, et al. Management of discoid lateral meniscus tears: observations in 34 knees. Arthroscopy. 2003;19(4):346-352. doi: 10.1053/jars.2003.50038.
19. Noble J, Hamblen DL. The pathology of the degenerate meniscus lesion. J Bone Joint Surg Br. 1975;57(2):180-186.
20. Fujikawa K, Iseki F, Mikura Y. Partial resection of the discoid meniscus in the child's knee. J Bone Joint Surg Br. 1981;63-B(3):391-395. doi: 10.1302/0301-620X.63B3.7263752.
21. Rohren EM, Kosarek FJ, Helms CA. Discoid lateral meniscus and the frequency of meniscal tears. Skeletal Radiol. 2001;30(6):316-320. doi: 10.1007/s002560100351.
22. Easley ME, Cushner FD, Scott WN. Arthroscopic meniscal resection. In: Insall JN, Scott WN, eds. Surgery of the Knee. Philadelphia, PA: Churchill Livingstone; 2001.
23. Pellacci F, Montanari G, Prosperi P, et al. Lateral discoid meniscus: treatment and results. Arthroscopy. 1992;8(4):526-530. doi: 10.1016/0749-8063(92)90020-c.
24. Smith CF, Van Dyk GE, Jurgutis J, et al. Cautious surgery for discoid menisci. Am J Knee Surg. 1999;12(1):25-28.
25. Kato Y, Oshida M, Aizawa S, et al. Discoid lateral menisci in Japanese cadaver knees. Mod Rheumatol. 2004;14(2):154-159. doi: 10.1007/s10165-004-0283-8.
26. Aichroth PM, Patel DV, Marx CL. Congenital discoid lateral meniscus in children: a follow-up study and evolution of management. J Bone Joint Surg Br. 1991;73(6):932-936. doi: 10.1302/0301-620X.-73B6.1955439.
27. Rao SK, Sripathi Rao P. Clinical, radiologic and arthroscopic assessment and treatment of bilateral discoid lateral meniscus. Knee Surg Sports Traumatol Arthrosc. 2007;15(5):597-601. doi: 10.1007/s00167-006-0262-