Lateral Meniscal Tears in Young Patients

A Comparison of Meniscectomy and Surgical Repair

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Background: Meniscal tears are common in active patients, but treatment trends and surgical outcomes in young patients with lateral meniscal tears are lacking.

Purpose: To evaluate treatment trends, outcomes, and failure rates in young patients with lateral meniscal tears.

Study Design: Cohort study; Level of evidence, 3.

Methods: Patients aged ≤25 years treated surgically for isolated lateral meniscal tears from 2001 to 2017 were identified. Treatment trends were compared over time. International Knee Documentation Committee (IKDC) scores and failure rates were compared by treatment modality (meniscectomy vs meniscal repair). Failure was defined as reoperation, symptomatic osteoarthritis, or a severely abnormal IKDC score. Univariate regression analyses were performed to predict failure and IKDC scores based on treatment, type and location of tear, or extent of meniscectomy.

Results: Included were 217 patients (226 knees) with a mean age of 17.4 years (range, 7-25 years); of these patients, 144 knees (64%) were treated with meniscectomy and 82 knees (36%) with meniscal repair. Treatment with repair increased over time compared with meniscectomy ($P < .001$). At a minimum 2-year follow-up (mean, 6.1 ± 3.9 years), 107 patients (110 knees) had IKDC scores, and analysis indicated that although scores in both groups improved from pre- to postoperatively (repair: from 69.5 ± 13.3 to 97.4 ± 4.3; meniscectomy: from 75.7 ± 9.0 to 97.3 ± 3.9; $P < .001$ for both), improvement in IKDC score was greater after repair (27.9 ± 13.9) versus meniscectomy (21.6 ± 9.4) ($P = .005$). Included in the failure analysis were 184 patients (192 knees) at a mean follow-up of 8.4 ± 4.4 years. The rates of reoperation, symptomatic osteoarthritis, and failure were not significantly different between the meniscectomy and repair groups.

Conclusion: An increase was seen in the rate of isolated lateral meniscal tear repair in young patients. IKDC score improvement was greater after repair than meniscectomy, although postoperative IKDC scores were similar. Symptomatic arthritis, reoperation, and failure rates were similar between groups; however, there was a trend for increased arthritis symptoms in patients treated with meniscectomy, especially total meniscectomy. Treatment modality, type and location of tear, and amount of meniscus removed were not predictive of final IKDC scores or failure.

Keywords: lateral meniscus; meniscal repair; meniscectomy

The lateral meniscus contributes to load transmission across the femorotibial joint and functions to improve joint stability by increasing joint congruency.[20] Meniscal tears occur at an incidence of 8.27 per 1000 person-years.[12] The rate of isolated lateral meniscal tears in young adults is not reported in the literature. Although there is a paucity of literature directly investigating lateral meniscal tears, previous studies[3,16] have shown that the degree and pattern of tear, as well as method of treatment, can have profound impacts on the longevity of the knee and patient outcomes, with total or subtotal meniscectomy leading to early arthrosis. Tear patterns are generally classified as simple or complex based on single or multiple planes of tearing, respectively, and simple patterns can be further subdivided by specific tear pattern.[7] Treatment of meniscal tears varies from nonoperative management to partial or total meniscectomy or meniscal repair.[8]

Long-term sequelae of isolated meniscal tears include knee pain and articular cartilage degeneration. Partial meniscal resection can lead to higher rates of subsequent arthritis when compared with meniscal repair.[23] Radial, root,[15] and complex tear patterns treated with total or near-total meniscectomy result in loss of hoop stress resistance and rapid knee degeneration.[3,17] Repair has recently become more common, according to a survey of practice trends. Treatment selection clearly affects results[18]; however, surgical outcomes in young patients with isolated lateral meniscal tears are lacking.

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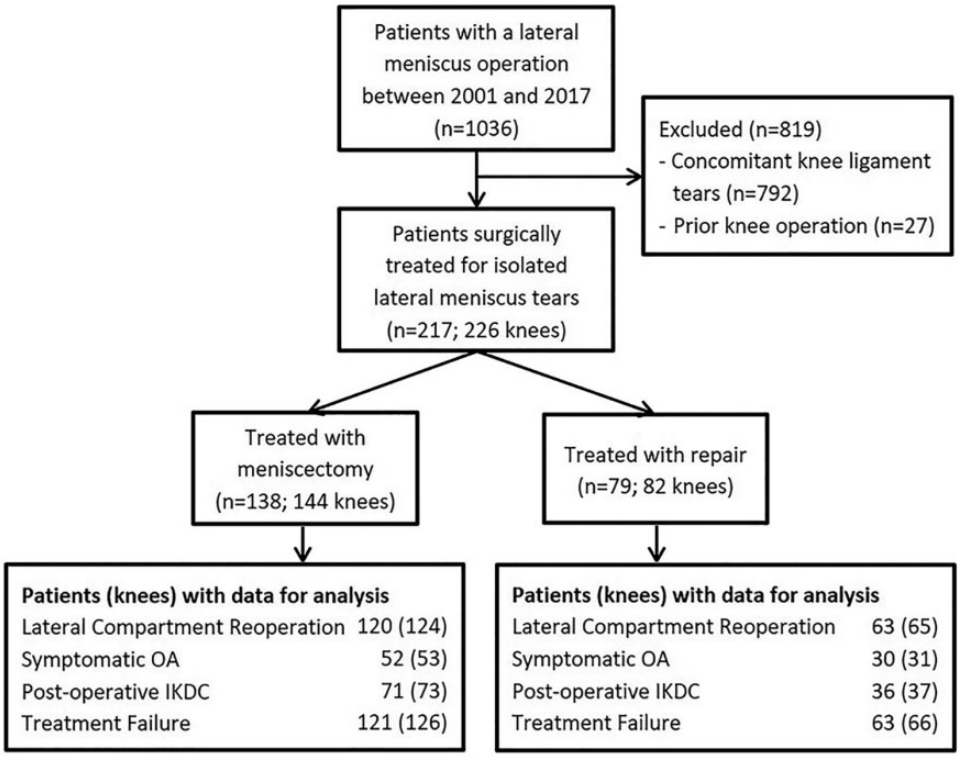

Figure 1. Flowchart showing the application of inclusion and exclusion criteria. Reoperation, International Knee Documentation Committee (IKDC) score, and treatment failure analyses required 2-year clinical follow-up for inclusion, and symptomatic osteoarthritis (OA) analysis required postoperative radiographs at a minimum of 2 years. If patients underwent lateral compartment reoperation before 2 years, they were considered in the reoperation and treatment failure analyses. Patients who met the definition for symptomatic OA before 2 years were included in the symptomatic OA and treatment failure analyses.

We describe our experience with lateral meniscal tears in young patients, including (1) surgical treatment trends for both meniscectomy and meniscal repair, (2) midterm patient-reported outcomes (PRO; International Knee Documentation Committee [IKDC] score), and (3) failure rates and risk factors for failure. We hypothesized that repair has increased over time; PRO scores are higher with repair; radiographic evidence of symptomatic joint degeneration is decreased in patients who undergo repair; and midterm failure (reoperation, osteoarthritis [OA], or severely abnormal IKDC score) is higher in patients who undergo total meniscectomy.

METHODS

Patients

After receiving study approval from our institutional review board, we reviewed the records of all patients aged 25 years and younger who underwent surgical treatment of lateral meniscal tears from 2001 to 2017. Patients with concomitant knee ligament tears or previous knee surgery were excluded. A total of 217 patients (226 knees) were identified and included (Figure 1). Pre- and postoperative notes were reviewed to identify patient and injury characteristics. Operative notes were reviewed to determine tear

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Ethical approval for this study was obtained from Mayo Clinic (application No. 15-000601).

TABLE 1
Patient Characteristics[a]

Variable	Meniscectomy (n = 138 Patients; 144 Knees)	Repair (n = 79 Patients; 82 Knees)	P
Sex			
Male	102 (74)	56 (71)	.630
Female	36 (26)	23 (29)	
Age, y	17.3	17.7	.424
BMI, kg/m^2	26.6	26	.522
Onset			
Acute	90 (65)	54 (68)	.638
Chronic	48 (35)	25 (32)	
Activity level			
Sedentary	9 (7)	5 (6)	.749
Recreational	31 (22)	17 (22)	
Competitive	96 (70)	57 (72)	
Unknown	2 (1)	—	
Smoker			
Yes	19 (14)	7 (9)	.251
No	106 (77)	68 (86)	
Unknown	13 (9)	4 (5)	

[a]Data are reported as No. of patients (%) or mean value. BMI, body mass index.

pattern/type, chondral injury, and treatment details. Electronic medical records were searched for reoperations, postoperative imaging, and patient outcome scores at final follow-up.

Treatment Trends

All 217 patients (226 knees) were included in the treatment-trend analysis. Surgical treatment modality (meniscal repair vs meniscectomy) was obtained from operative notes along with tear pattern, size, location, amount of meniscus removed (meniscectomy group), and repair technique. Indications for repair technique were surgeon-dependent and included all-inside, outside-in, inside-out, and hybrid techniques. Treatment modality was compared on an annual basis throughout the study period.

Outcomes

Patients with IKDC scores at a minimum of 2 years after surgery were included in the outcome analysis. IKDC scores were obtained preoperatively and at final follow-up. These scores have been validated for use in patients treated for meniscal injury.[5,24] IKDC scores were compared based on treatment modality. Outcomes after meniscal repair were compared with outcomes after removal of >25% of the meniscus and total meniscectomy.

Failure Rates

Patients were included in the failure analysis if they underwent reoperation for the lateral compartment, had symptomatic OA at any point after their primary lateral meniscal operation, or had a minimum 2-year follow-up.

TABLE 2
Tear Patterns[a]

Type of Tear	Meniscectomy	Repair
Complex	36 (25.0)	8 (9.8)
Radial	33 (22.9)	11 (13.4)
Oblique flap	24 (16.7)	2 (2.4)
Horizontal cleavage	21 (14.6)	2 (2.4)
Bucket handle	18 (12.5)	35 (42.7)
Vertical longitudinal	6 (4.2)	21 (25.6)
Other	6 (4.2)	3 (3.7)

[a]Data are reported as No. of knees (%).

Treatment failure was defined as reoperation for the lateral compartment, symptomatic OA, or IKDC rating of severely abnormal, defined as <75.4 as per the IKDC guidelines.[10] Radiographs were graded using the Kellgren-Lawrence scale. Symptomatic arthritis was defined as pain or mechanical symptoms that warranted physician consultation and radiographs showing a Kellgren-Lawrence grade ≥1.

Statistical Analysis

Treatment modality was compared on an annual basis throughout the study period using the Pearson chi-square test. Continuous variables were analyzed by treatment group using the Student *t* tests. Subgroup analysis was conducted to determine if treatment modality varied depending on tear complexity or pattern and if this relationship persisted over time using chi-square analysis or Fisher exact tests. Outcomes after removal of >25% of the meniscus and subtotal/total meniscectomy were evaluated using Student *t* tests for IKDC scores and chi-square analysis for failure rates. Univariate linear regression analysis for prediction of IKDC score and logistic regression for failure were conducted using treatment type, location of tear, tear type, and amount of meniscus removed. Student *t* tests were conducted to compare failure rates based on treatment modality. Level of significance was defined as an alpha value of 0.05. A post hoc analysis was performed to evaluate study power. This demonstrated 35.3% power for meniscectomy versus repair for symptomatic OA with 111 patients needed per study group, and 3.3% power for postoperative IKDC score with 48,478 patients needed per treatment group.

RESULTS

Comprehensive patient characteristics are listed in Table 1. Of the 217 patients, 158 were male, with a mean age of 17.4 years (range, 7-25 years). A total of 138 patients (64%; 144 knees) were treated with meniscectomy, and 79 patients (36%; 82 knees) were treated with repair. Tear pattern and location are shown in Tables 2 and 3, respectively. Outcomes of the meniscectomy group by amount of meniscus removed are shown in Table 4.

TABLE 3
Tear Location[a]

Anatomic Position	Meniscectomy	Repair
Body	78 (54.2)	24 (29.3)
Posterior horn	32 (22.2)	34 (41.5)
Multiple locations	18 (12.5)	19 (23.2)
Anterior horn	16 (11.1)	5 (6.1)

[a]Data are reported as No. of knees (%).

TABLE 4
Outcomes by Amount of Meniscus Removed in Patients With Meniscectomy[a]

	Amount Removed[b]			
	>75%	25%-75%	<25%	*P*
Overall	17 (23)	59 (82)	24 (33)	
Postoperative IKDC score (No. of knees)	97.5 (13)	97.2 (44)	97.2 (15)	.861
Lateral compartment reoperation	17 (3)	19 (14)	17 (5)	>.999
Symptomatic OA	50 (4)	27 (8)	36 (5)	.423

[a]Data are reported as percent (No. of knees) unless otherwise indicated. IKDC, International Knee Documentation Committee; OA, osteoarthritis.
[b]Of the 144 knees, 6 were missing data for amount of meniscus removed.

Treatment Trends

All 217 patients (226 knees) were included in the treatment-trend analysis. Treatment rates for meniscal repair increased over time compared with meniscectomy, with 63% of lateral meniscal tears from 2013 to 2017 treated with repair compared with 23% from 2001 to 2004 ($P < .001$). In total, 54.9% of menisci treated with repair occurred from 2013 to 2017 compared with 15.9% of repairs taking place from 2001 to 2004. Overall trends are represented in Figure 2. Subgroup analysis of specific tear types over time showed a statistically significant trend in treatment for radial tears ($P < .001$), complex tears ($P < .001$), and horizontal cleavage tears ($P = .049$). The earliest repair of complex and horizontal cleavage tears occurred between 2013 and 2017, and only 1 radial tear was repaired before the 2013 to 2017 period. Treatment trends for bucket-handle, oblique-flap, and vertical-longitudinal tears were not different over time.

Outcomes

In total, 107 patients (49.3%) had an IKDC score at a minimum of 2 years (mean, 6.1 ± 3.9 years). Of those patients, 71 (73 knees) underwent meniscectomy, and 36 (37 knees) underwent repair. The mean preoperative IKDC score in the meniscectomy group was 75.7 ± 9.0, and it increased to 97.3 ± 3.9 postoperatively ($P < .001$). In the repair group,

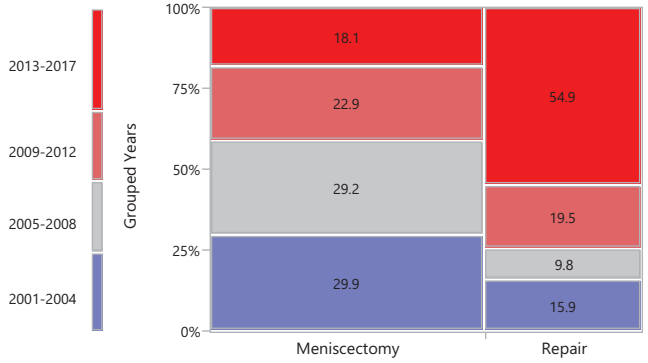

Figure 2. Meniscectomy and repair trends over time. Inset labels represent percentage of the respective treatment occurring within the corresponding year range. Column widths are proprotional to the number of patients in each treatment group.

the mean preoperative IKDC score was 69.5 ± 13.3, and it increased to 97.4 ± 4.3 postoperatively ($P < .001$). The mean pre- to postoperative improvement in IKDC score was greater in the repair group compared with the meniscectomy group (27.9 ± 13.9 vs 21.6 ± 9.4; $P = .005$). Postoperative IKDC scores in the repair group were similar to the IKDC scores for the subtotal/total meniscectomy group (97.5 ± 3.5; $P = .899$) and the group with >25% of the meniscus removed (97.3 ± 3.9, $P = .918$). Univariate regression analyses for prediction of IKDC did not reach significance when treatment type ($P = .930$), location of tear ($P = .698$), tear type ($P = .949$), and amount of meniscus removed ($P = .555$) were used as predictors in separate models.

Failure Rates

In total, 184 patients were included in the failure analysis. Of those, 181 had a clinical follow-up of at least 2 years (mean, 8.4 ± 4.4 years). Seven patients underwent reoperation before 2 years. In total, 22 patients (18%) underwent reoperation in the meniscectomy group compared with 15 patients (23%) in the repair group ($P = .380$).

With regard to reoperation of the lateral compartment in the meniscectomy group, 12 patients underwent repeat meniscectomy, 2 underwent meniscal repair, 4 underwent chondroplasty, 2 received a combination of chondroplasty and repeat meniscectomy, 1 patient was treated with an osteochondral autograft transfer, and 1 patient received a femoral condyle osteochondral allograft and meniscal allograft. For reoperation in the repair group, 1 underwent open debridement for postoperative infection, 5 received a repeat repair, 8 underwent meniscectomy, and 1 patient had a subsequent chondroplasty.

Postoperative radiographs more than 2 years after surgery were available for 75 patients (34.6% of total cohort); an additional 7 patients had symptomatic OA before 2 years. Seventeen patients (32%) in the meniscectomy group had symptomatic OA compared with 5 patients (16%) in the repair group ($P = .109$). Compared with the repair group, 4 patients (50%) in the subtotal/total meniscectomy group

TABLE 5
Treatment Failures[a]

	Meniscectomy	Repair	P
Lateral compartment reoperation	18 (22/124)	23 (15/65)	.380
Symptomatic OA[b]	32 (17/53)	16 (5/31)	.109
Postoperative IKDC <75.4[c]	0 (0/73)	0 (0/37)	—
Failure[d]	27 (34/126)	27 (18/66)	.966

[a]Data are reported as percent (No. of knees/total included). IKDC, International Knee Documentation Committee; OA, osteoarthritis.

[b]n = 84 knees in 82 patients with radiographs at ≥2-year follow-up or symptomatic OA before 2-year follow-up.

[c]n = 110 knees in 107 patients with postoperative IKDC scores at 2 years.

[d]Failure defined as lateral compartment reoperation, IKDC score <75, or symptomatic osteoarthritis in patients with at least 2 years of follow-up or failure before 2 years.

had symptomatic OA ($P = .065$), and 12 patients (32%) in the group with >25% of the meniscus removed had symptomatic OA. No patient in either the repair or meniscectomy group had an IKDC score <75.4.

Overall, 34 patients (27%) in the meniscectomy group and 18 patients (27%) in the repair group were deemed treatment failures ($P = .966$) (Table 5). The rate of failure in the repair group was not significantly different from the rates of failure in the subtotal/total meniscectomy group (39%, $P = .339$) or the group with >25% of the meniscus removed (26%, $P = .776$). Logistic regression analyses to predict failure did not reach significance when treatment type ($P = .305$), location of tear ($P = .854$), tear type ($P = .415$), and amount of meniscus removed ($P = .134$) were used as predictors in separate models.

DISCUSSION

Treatment outcomes of lateral meniscal tears in the young patient are limited in the current literature. Our results demonstrate satisfactory treatment outcomes at midterm follow-up with both repair and meniscectomy, with repair becoming more common in recent years at our institution. Rates of symptomatic OA, reoperation, and failure were similar between groups. However, there is a trend of increased symptomatic OA in patients treated with meniscectomy, especially total meniscectomy. We report an overall clinical success rate of 73% in patients with a lateral meniscal tear who undergo meniscectomy or lateral meniscal repair. Clinical success was defined as no reoperation for the lateral compartment, no symptomatic OA, and postoperative IKDC score ≥75.4.

The study results indicate that over time, a larger proportion of lateral meniscal tears in this young population were treated with repair rather than meniscectomy. This is represented in Figure 2, with more than half of repairs taking place between 2013 and 2017 compared with the 12 preceding years. Conversely, there was a trend of performing fewer meniscectomies, with close to 30% of all meniscectomies being performed between 2001 and 2004, with decreasing percentages annually. Subgroup analysis also showed that horizontal cleavage along with more difficult tear patterns, such as complex (multiplanar) and radial tears, were being repaired more frequently. Treatment trends for bucket-handle, oblique-flap, and vertical-longitudinal tears did not change over time.

Parker et al[18] described practice patterns of American Board of Orthopaedic Surgery members from 2004 to 2012 and also showed a 37% increase in meniscal repair over this 9-year time period as well as a 17% decrease in meniscectomy procedures. Their study did not separate medial or lateral meniscal tears. Abrams et al[1] reviewed the PearlDiver Patient Record Database, which represents 9% of patients in the United States who are younger than 65 years of age. They showed a doubling in the incidence of meniscal repairs from 2005 and 2011 but also showed a 14% increase in the incidence of meniscectomy over this same time period. The same trend seems to be occurring outside of the United States as well, with 7.2% of patients in Japan undergoing meniscal repair in 2007 compared with 25.9% in 2014 and the 92.8% meniscectomy rate in 2007 falling to 73.3% in 2014. Most patients undergoing meniscal repair in this study were 10 to 19 years of age.[13] Jacquet et al[11] reported similar trends in France, with a 21.4% reduction in meniscectomy procedures from 2005 and 2017 and a 32.0% increase in repair over this same time period. Our data align with the literature showing increased rates of repair, and to our knowledge, this is the first time this is reported specifically regarding the lateral compartment.

In this study, we found a statistically significant improvement from preoperative to postoperative IKDC scores in both the meniscectomy and repair groups. On average, scores increased by 21.6 points in the meniscectomy group compared with an increase of 27.9 points in the repair group. Postoperative IKDC scores did not differ between repair and meniscectomy; however, the repair group started with a lower preoperative IKDC score. No patients in either group had an IKDC score <75.4 at the final follow-up. In these patients, tear location, type, and amount of meniscectomy were not predictive of IKDC scores.

Paxton et al[19] conducted a systematic review comparing partial meniscectomy to repair and showed higher Lysholm scores and less radiographic degeneration in patients who underwent repair compared with partial meniscectomy.[19] Krych et al[14] reviewed the results of isolated meniscal tears in skeletally immature patients younger than 18 years treated with meniscal repair. At an average follow-up of 5.8 years (range, 2.5 months-13.8 years), they reported an IKDC score of 89.4 and that complex tears and a rim width >3 mm were risk factors for failure. Salata et al[22] conducted a systematic review of patients with meniscectomy and found an association between total meniscectomy and lateral meniscectomy and poor clinical outcomes. The mean follow-up of their included studies ranged from 7.8 to 21 years,[2,4,6,9,21] compared with our shorter time period of 6.1 years.

We found a 27% failure rate in patients treated with lateral meniscectomy (34 patients) and a 27% failure rate in patients treated with lateral meniscal repair (18 patients). Our reoperation rates in the meniscectomy group and repair group were similar, at 18% for the meniscectomy group and 23% for the repair group, which did not reach statistical significance. More patients in the meniscectomy group had symptomatic OA compared with patients who underwent repair, showing rates of 32% and 16%, respectively; however, this also did not reach statistical significance. Our rate of failure was increased in the >75% (subtotal/total) meniscectomy group at 39% failure, but not in patients with >25% of their meniscus resected (26% failure).

Conversely, Paxton et al[19] reported a lower reoperation rate with partial meniscectomy, which was 3.9% compared with 20.7% in the repair group at long-term follow-up. The reoperation rate of partial lateral meniscectomy was higher than the reoperation rate of partial medial meniscectomy. Also, repairs of the lateral meniscus had a slightly lower reoperation rate than repairs of the medial meniscus. Our study includes patients with near-total and total lateral meniscectomy, which likely explains our higher reoperation rate in our meniscectomy cohort. In the previously discussed study by Krych et al[14] evaluating meniscal repair in young patients, they reported a success rate of 80% for simple tears, 68% for bucket-handle tears, and 13% for complex tears. Our success rate of repair in the lateral compartment (73%) was comparable to their study based on our tear complexity distribution.

Limitations

This retrospective study has multiple limitations, including inconsistent radiographic follow-up and the lack of postoperative magnetic resonance imaging or second-look arthroscopy to capture repair failures or advancement in lateral compartment degeneration. Long-leg radiographs were not evaluated; therefore, the contribution of limb alignment was not included. Data on red-red, red-white, and white-white zones of meniscus were not consistently recorded in operative reports. Additionally, midterm length of follow-up may not have allowed adequate time for joint degeneration. Lastly, functional scores were obtained for only a portion of patients.

This study has multiple strengths, as the first report assessing surgical management exclusively of the lateral meniscus in a young population. The patient numbers are also a strength, given the infrequency of meniscal repairs in this young population.

CONCLUSION

The rate of isolated lateral meniscal tear repair in young patients at our institution has increased. IKDC score improvement is greater after repair than meniscectomy, although postoperative IKDC scores are similar. Symptomatic arthritis, reoperation, and failure rates were similar between groups; however, there was a trend for increased arthritis symptoms in patients treated with meniscectomy, especially total meniscectomy. Treatment modality, type and location of tear, and amount of meniscus removed were not predictive of final IKDC scores or failure.

REFERENCES

1. Abrams GD, Frank RM, Gupta AK, et al. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. *Am J Sports Med*. 2013;41(10):2333-2339.
2. Andersson-Molina H, Karlsson H, Rockborn P. Arthroscopic partial and total meniscectomy: a long-term follow-up study with matched controls. *Arthroscopy*. 2002;18(2):183-189.
3. Baratz ME, Fu FH, Mengato R. Meniscal tears: the effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. *Am J Sports Med*. 1986;14(4):270-275.
4. Bonneux I, Vandekerckhove B. Arthroscopic partial lateral meniscectomy long-term results in athletes. *Acta Orthop Belg*. 2002;68(4):356-361.
5. Briggs KK, Kocher MS, Rodkey WG, Steadman JR. Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for patients with meniscal injury of the knee. *J Bone Joint Surg Am*. 2006;88(4):698-705.
6. Englund M, Lohmander LS. Risk factors for symptomatic knee osteoarthritis fifteen to twenty-two years after meniscectomy. *Arthritis Rheum*. 2004;50(9):2811-2819.
7. Greis PE, Bardana DD, Holmstrom MC, Burks RT. Meniscal injury: I. Basic science and evaluation. *J Am Acad Orthop Surg*. 2002;10(3):168-176.
8. Greis PE, Holmstrom MC, Bardana DD, Burks RT. Meniscal injury: II. Management. *J Am Acad Orthop Surg*. 2002;10(3):177-187.
9. 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(1):118-121.
10. Irrgang JJ, Ho H, Harner CD, Fu FH. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 1998;6(2):107-114.
11. Jacquet C, Pujol N, Pauly V, Beaufils P, Ollivier M. Analysis of the trends in arthroscopic meniscectomy and meniscus repair procedures in France from 2005 to 2017. *Orthop Traumatol Surg Res*. 2019;105(4):677-682.
12. Jones JC, Burks R, Owens BD, et al. Incidence and risk factors associated with meniscal injuries among active-duty US military service members. *J Athl Train*. 2012;47(1):67-73.
13. Kawata M, Sasabuchi Y, Taketomi S, et al. Annual trends in arthroscopic meniscus surgery: analysis of a national database in Japan. *PLoS One*. 2018;13(4):e0194854.
14. Krych AJ, McIntosh AL, Voll AE, Stuart MJ, Dahm DL. Arthroscopic repair of isolated meniscal tears in patients 18 years and younger. *Am J Sports Med*. 2008;36(7):1283-1289.
15. Krych AJ, Reardon PJ, Johnson NR, et al. Non-operative management of medial meniscus posterior horn root tears is associated with worsening arthritis and poor clinical outcome at 5-year follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(2):383-389.
16. Manzione M, Pizzutillo PD, Peoples AB, Schweizer PA. Meniscectomy in children: a long-term follow-up study. *Am J Sports Med*. 1983;11(3):111-115.
17. Papalia R, Del Buono A, Osti L, Denaro V, Maffulli N. Meniscectomy as a risk factor for knee osteoarthritis: a systematic review. *Br Med Bull*. 2011;99:89-106.
18. Parker BR, Hurwitz S, Spang J, Creighton R, Kamath G. Surgical trends in the treatment of meniscal tears: analysis of data from the American Board of Orthopaedic Surgery certification examination database. *Am J Sports Med*. 2016;44(7):1717-1723.

19. Paxton ES, Stock MV, Brophy RH. Meniscal repair versus partial meniscectomy: a systematic review comparing reoperation rates and clinical outcomes. *Arthroscopy*. 2011;27(9):1275-1288.
20. Petersen W, Tillmann B. Collagenous fibril texture of the human knee joint menisci. *Anat Embryol (Berl)*. 1998;197(4):317-324.
21. Roos H, Lauren M, Adalberth T, et al. Knee osteoarthritis after meniscectomy: prevalence of radiographic changes after twenty-one years, compared with matched controls. *Arthritis Rheum*. 1998;41(4):687-693.
22. Salata MJ, Gibbs AE, Sekiya JK. A systematic review of clinical outcomes in patients undergoing meniscectomy. *Am J Sports Med*. 2010;38(9):1907-1916.
23. Stein T, Mehling AP, Welsch F, von Eisenhart-Rothe R, Jager A. Long-term outcome after arthroscopic meniscal repair versus arthroscopic partial meniscectomy for traumatic meniscal tears. *Am J Sports Med*. 2010;38(8):1542-1548.
24. van de Graaf VA, Wolterbeek N, Scholtes VA, Mutsaerts EL, Poolman RW. Reliability and validity of the IKDC, KOOS, and WOMAC for patients with meniscal injuries. *Am J Sports Med*. 2014;42(6):1408-1416.