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Meniscal Repair Outcomes at Greater Than Five Years

A Systematic Literature Review and Meta-Analysis

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Background: Meniscal repair offers the potential to avoid the long-term articular cartilage deterioration that has been shown to result after meniscectomy. Failure of the meniscal repair can occur several years postoperatively. Limited evidence on the long-term outcomes of meniscal repair exists.

Methods: We performed a systematic review of studies reporting the outcomes of meniscal repair at a minimum of five years postoperatively. Pooling of data and meta-analysis with a random-effects model were performed to evaluate the results.

Results: Thirteen studies met the inclusion criteria. The pooled rate of meniscal repair failure (reoperation or clinical failure) was 23.1% (131 of 566). The pooled rate of failure varied from 20.2% to 24.3% depending on the status of the anterior cruciate ligament (ACL), the meniscus repaired, and the technique utilized. The rate of failure was similar for the medial and the lateral meniscus as well as for patients with an intact and a reconstructed ACL.

Conclusions: A systematic review of the outcomes of meniscal repair at greater than five years postoperatively demonstrated very similar rates of meniscal failure (22.3% to 24.3%) for all techniques investigated. The outcomes of meniscal repair at greater than five years postoperatively have not yet been reported for modern all-inside repair devices.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Meniscal tears are the most commonly treated knee injury^{1,2}. The meniscus is vital to normal function and longevity of the knee, as meniscal loss causes increased contact pressures and articular cartilage degeneration³⁻⁸. Meniscal repair techniques have evolved substantially in the last few decades, with open techniques replaced by arthroscopic techniques. Arthroscopic techniques have evolved as well and include inside-out, outside-in, and all-inside repairs. All-inside repair devices continue to evolve, with numerous devices currently available. Inside-out and all-inside repairs are most commonly used today.

Although numerous studies have reported one to two-year outcomes of meniscal repair, reports of outcomes at greater than

five years are limited⁹. The failure rate of meniscal repair increases from early to long-term follow-up¹⁰. Numerous authors have reported failures at greater than two years postoperatively¹⁰⁻¹⁹, yet most published studies focus on short-term outcomes⁹. We performed a systematic literature review and meta-analysis to better define the rate of clinical failure after meniscal repair at greater than five years postoperatively. We hypothesized that the overall successful results noted at short-term follow-up would be maintained at longer-term follow-up. Utilizing pooled data and meta-analysis with a random-effects model, we determined the effect of repair type, medial or lateral location, and anterior cruciate ligament (ACL) status on the failure rate as indicated by the currently available literature.

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Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.



A commentary by Armando F. Vidal, MD, is linked to the online version of this article at jbjs.org.

Materials and Methods

Literature Review

We performed a systematic literature review to determine the outcomes of meniscal repair at greater than five years postoperatively. Inclusion criteria included a primary outcome of meniscal repair status, a minimum of five years of follow-up for all patients in the cohort, primarily adult patients, a cohort size of greater than ten patients, $\leq 30\%$ loss to follow-up, and English-language publication. MEDLINE (January 1, 1966, to April 1, 2010), and Embase (January 1, 1974, to April 1, 2010) were queried with use of the terms ([meniscus OR meniscal] AND repair). These queries returned 1097 and 1135 results, respectively. Additionally, the Cochrane database was queried and yielded no additional studies. After the publication of several additional potentially eligible studies during manuscript preparation was noted, the queries were repeated on June 24, 2011, specifically focusing on results published in 2010 and 2011. These additional queries yielded 172 and 235 results, respectively.

Two of the reviewers examined the citation information for each result from the databases for relevant studies. Sixty-seven potentially relevant studies were identified, and the abstracts (and if necessary full manuscripts) of these studies were reviewed. The bibliographies of all reviewed manuscripts were also reviewed to identify other potential studies.

Study Design

Thirteen studies (reporting on fourteen patient cohorts) met the inclusion criteria and were the focus of the present study¹⁰⁻²². The studies were published between 1989 and 2011. Two of the studies represented Level-III evidence (retrospective comparative studies), and eleven studies represented Level-IV evidence (retrospective case series). For multiple studies by the same authors, only one study was included unless clear information on the absence of overlap between the cohorts was available. When necessary, attempts were made to contact the authors of the included studies to clarify reported data or to obtain missing data. One study included a subgroup of inside-out repairs and a subgroup of all-inside repairs, whereas all of the other studies utilized a single technique. Both reviewers extracted data on the failure rate, medial or lateral meniscal location, ACL status and treatment, tear chronicity, vascular zone, and radiographic and clinical outcomes with use of a standardized data collection tool. The rate of follow-up averaged 88% and ranged from 70% to 100% (see Appendix).

Failure of the meniscal repair was defined as clinical failure according to the criteria of the individual study. This generally included recurrent mechanical symptoms. The majority of clinical failures required operative intervention, at which time a persistent or recurrent meniscal tear was confirmed. However, individuals with clear evidence of clinical failure who chose not to undergo surgical intervention were also included as failures. Particular attention was paid to ensuring that early failures that were mentioned in a study but not included in later follow-up data were identified. Any discrepancies in data extraction between reviewers were resolved by mutual agreement.

Statistical Methods

Pooled analysis was utilized to compare failure rates, including among subgroups when data allowed. The heterogeneity of the studies was assessed qualitatively as well as quantitatively with use of the chi-square test. In order to account for between-study variation, a random-effects model was developed in Review Manager (RevMan) (version 5; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark); this software utilizes the method of Dersimonian and Laird to calculate an overall pooled estimate of effect. That method uses an inverse-variance approach to adjust the study weights according to the extent of heterogeneity present among the effects reported in the individual studies²³. Random-effects models for tear location and ACL status were analyzed. In order to be included in the model, a study had to include patients with failure in each subgroup (e.g., ACL-deficient and ACL-intact) so that a comparison could be made.

Source of Funding

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tional Institutes of Health and by a Career Development Supplement Award from the American Orthopaedic Society for Sports Medicine (AOSSM).

Results

A total of fourteen cohorts in thirteen studies were included. The repair technique was open in five cohorts^{11-13,15,21}, inside-out in five^{14,18-20,22}, outside-in in one¹⁶, and all-inside (with use of meniscal arrows) in three^{10,17,22}. The Appendix summarizes the patient populations and follow-up durations of the included studies. A total of 566 knees were included, with an overall failure rate of 23.1% (131 of 566) at greater than five years. Results of all-inside repair were limited to techniques involving meniscal arrows, with no reports available on more recent implants. The minimum duration of follow-up in the studies ranged from five to 11.9 years (mean, 7.4 years), and the studies included twenty to ninety-five knees. Steenbrugge et al.²² reported a meniscal failure rate of 0% at a minimum of 11.9 years postoperatively for inside-out repairs and a rate of 4.0% at a minimum of 11.9 years for all-inside repairs. The failure rates reported in all other studies were at least 16.0%.

Repair Technique

The failure rate of open meniscal repair at greater than five years ranged from 16.0% to 29.0% (see Appendix). Pooled analysis of open meniscal repair revealed a failure rate of 23.1% (thirty-three of 143). Two of the cohorts^{12,15} in the analysis included only ACL-intact knees and had a pooled failure rate of 26.8% (fifteen of fifty-six); one cohort¹¹ included only ACL-deficient knees (generally treated with repair or extra-articular reconstruction) and had a failure rate of 21.9% (seven of thirty-two).

The failure rate of outside-in meniscal repair at greater than five years was reported in a single study¹⁶ to be 23.9% (twenty-one of eighty-eight). This cohort included only ACL-intact knees. No other studies of outside-in meniscal repair met the inclusion criteria for the study.

The failure rate of inside-out meniscal repair at greater than five years ranged from 0% to 26.9%. Pooled analysis of inside-out meniscal repair revealed a failure rate of 22.3% (forty-one of 184). One study²² reported no failures, whereas the failure rates of the other four studies were 26.9%, 26.7%, 23.7%, and 20.7%. One study¹⁸ included thirty-five knees treated with ACL reconstruction in addition to meniscal repair; the failure rate was 28.6% (ten of thirty-five). Two studies^{14,20} included only ACL-intact knees and had failure rates of 26.9% and 23.7%.

The failure rates of all-inside meniscal repair at greater than five years were 4.0%, 28.4%, and 28.6%. Pooled analysis of all-inside meniscal repair revealed a failure rate of 24.3% (thirty-six of 148). One study¹⁰ included ACL-deficient knees treated with reconstruction and had a failure rate of 28.6% (eight of twenty-eight).

Tear Location

Eight studies^{12,13,15,16,18-20,22} included detailed information on the location (medial or lateral) of meniscal repairs as well as the location of failures. The pooled data included 190 repairs of the medial meniscus and 119 repairs of the lateral meniscus.

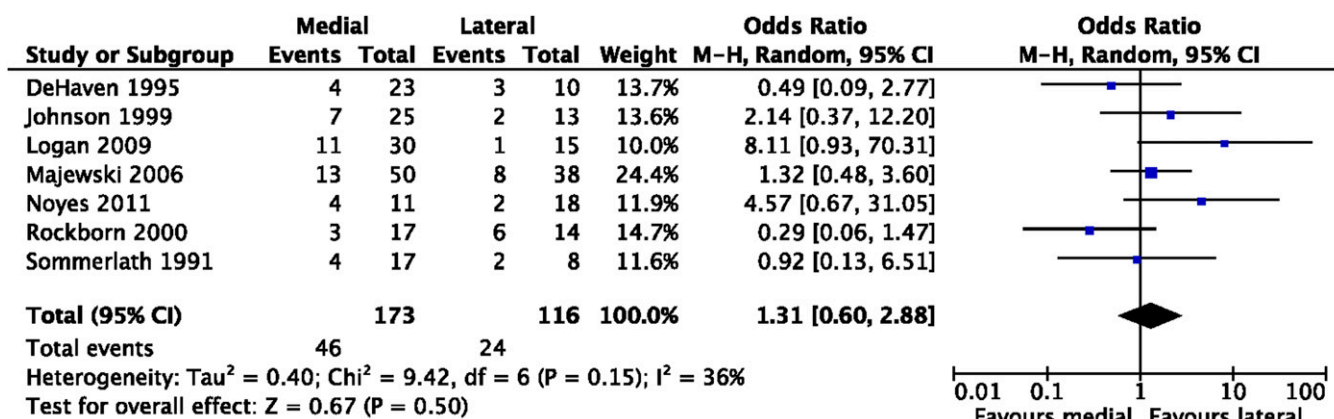


Fig. 1

Random-effects model for the effect of meniscal tear location (medial or lateral) on the failure rate. M-H = Mantel-Haenszel, CI = confidence interval, and df = degrees of freedom.

The pooled failure rate for medial meniscal repair was 24.2% (forty-six of 190) compared with 20.2% (twenty-four of 119) for lateral meniscal repair. Among studies reporting failures, the failure rate of medial meniscal repair ranged from 17.4% to 36.7%, whereas the failure rate for lateral meniscal repair ranged from 6.7% to 42.9%. The rate of meniscal repair failure was higher in the medial meniscal repairs in four studies^{16,18-20}, whereas the opposite was true in three other studies^{12,13,15}.

A random-effects model for tear location did not show a significant difference in the failure rate ($p = 0.17$). A nonsignificant trend toward a slightly lower failure rate in lateral meniscal repairs was observed (Fig. 1).

ACL Status

Nine groups in eight studies^{12-16,18,20,22} included a subset of ACL-intact patients, and six groups in five studies^{10,11,13,18,22} included a subset of ACL-deficient patients. Three groups^{10,18,22} included a subset of patients treated with ACL reconstruction. The pooled rate of meniscal repair failure for ACL-intact knees was 22.7% (sixty-three of 278). The pooled rate of meniscal repair failure for ACL-deficient knees was 22.1% (thirty of 136), including 26.9% (eighteen of sixty-seven) for ACL-reconstructed knees.

A random-effects model for ACL status did not show a significant effect on the failure rate of meniscal repair ($p = 0.86$,

Fig. 2). However, only three studies allowed for direct comparison between ACL-deficient and ACL-intact knees, with fifteen and four failures, respectively, in these groups.

Rehabilitation

Twelve studies provided details regarding the weight-bearing status and immobilization utilized during postoperative rehabilitation. Older studies, including those using open repair techniques, were more likely to utilize strict non-weight-bearing and immobilization postoperatively. Four studies^{11,12,14,15} utilized strict non-weight-bearing and had a pooled failure rate of 25.7% (thirty-six of 140). Seven studies^{13,16-19,21,22} (eight groups) utilized partial weight-bearing and had a pooled failure rate of 21.7% (78 of 360). A single study allowed full weight-bearing in a brace and had a failure rate of 28.6% (eight of twenty-eight)¹⁰. Six studies^{11-15,21} utilized immobilization in a cast or splint postoperatively for at least four weeks and had a pooled failure rate of 23.7% (forty-seven of 198). Six studies^{10,16-19,22} (seven groups) allowed some degree of gentle early range of motion and had a pooled failure rate of 22.7% (seventy-five of 330).

Other Factors

Four groups in three studies^{13,15,22} included detailed information on the chronicity of the meniscal tears. Utilizing the definitions

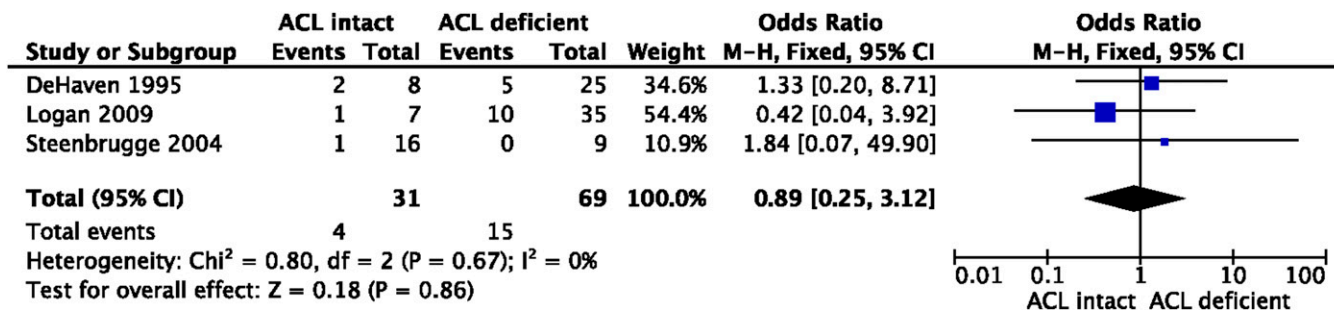


Fig. 2

Random-effects model for the effect of anterior cruciate ligament (ACL) status (intact or deficient) on the failure rate. M-H = Mantel-Haenszel, CI = confidence interval, and df = degrees of freedom.

of acute and chronic tears provided in the individual studies, the pooled failure rates were 16.3% (eight of forty-nine) for acute tears and 15.5% (nine of fifty-eight) for chronic tears. Seven groups in six studies^{13,15,19-22} included detailed information on the vascular zone of the meniscal tears. Red-red meniscal zone repair had a pooled failure rate of 20.9% (twenty-nine of 139). Noyes et al.¹⁹ reported a failure rate of 20.7% (six of twenty-nine) for red-white meniscal tears. Limited information on meniscal tears in the white-white zone was present.

Timing of Failure

Six studies^{11,12,14,15,17,19} provided detailed information on repair failures occurring after two years postoperatively. Meniscal repair failures presenting two years or more postoperatively comprised 14.3% to 55.6% of all meniscal repair failures. Pooling of these studies revealed late failure (at more than two years) to represent 29.0% (twenty of sixty-nine) of all meniscal repair failures. Four other studies^{10,13,16,18} reported the mean length of time to meniscal failure, which ranged from 2.2 to 4.2 years postoperatively.

Other Outcomes

Six studies reported Lysholm knee scores after medium to long-term follow-up. Three studies^{12,13,15} indicated the mean Lysholm knee score for all meniscal repairs, with scores of 90, 95, and 96, respectively. Similarly, these studies reported Lysholm scores of >80 in 81% to 100% of patients. Five studies^{11,13,15-17} indicated the mean Lysholm score of the subgroup with successful meniscal repair, which ranged from 88 to 95. Two studies^{13,15} reported the mean Lysholm score of the subgroup with failed meniscal repair, which was 84 and 86, respectively (compared with 92 and 95 for the successful meniscal repair subgroup in the same study). Three studies^{10,14,17} indicated the mean International Knee Documentation Committee (IKDC) score in the subgroup with successful meniscal repair, with 90% to 100% having a normal or near-normal score.

Osteoarthritis

Five studies^{12-15,20} reported the prevalence of radiographic findings of osteoarthritis in all meniscal repairs with use of the Fairbank and/or Ahlbach classifications. The prevalence of radiographic findings of osteoarthritis ranged from 8% to 25%. These changes were generally mild (grade 1). Similarly, five studies^{13,15,16,19,21} reported the prevalence of radiographic findings of osteoarthritis in successful repairs, which ranged from 14% to 28%. Two studies^{13,15} allowed direct comparison of the prevalence of radiographic findings of osteoarthritis between successful and failed meniscal repairs. Both indicated higher rates of radiographic changes in failed repairs (56% compared with 14% and 57% compared with 15%, respectively).

Discussion

This systematic review of the outcomes of meniscal repair at greater than five years postoperatively demonstrated very similar rates of meniscal failure (22.3% to 24.3%) for all

techniques. No outcomes of meniscal repair at greater than five years postoperatively have been reported for more recently developed all-inside devices. No significant difference in the rate of meniscal repair failure at long-term follow-up was seen for ACL-intact compared with ACL-deficient knees. The pooled rate of failure of medial meniscal repairs (24.2%) was slightly greater than that of lateral meniscal repairs (20.2%). Approximately 30% of all failures occurred after two years postoperatively. Our hypothesis regarding the maintenance of successful results at longer follow-up was not supported by the data, as the rate of repair failures was increased at intermediate-term follow-up compared with previously reported short-term results⁹.

Although numerous studies have reported short-term outcomes of various techniques of meniscal repair, relatively few have reported medium to long-term outcomes. Failure of meniscal repair after two years was not infrequent. In the present study, failures after two years represented nearly 30% of all failures. Additionally, in studies reporting the mean time to failure, the mean was uniformly greater than two years. Thus, the rate of meniscal repair failure appears to increase from short-term follow-up to medium to long-term follow-up. Lee and Diduch¹⁰ demonstrated an increase in the failure rate of meniscal repair with use of meniscal arrows from 9.4% at a mean of 2.3 years postoperatively to 28.6% at a mean of 6.6 years. An increase in the failure rate is likely to occur regardless of the repair technique and device. Lozano et al.⁹ reviewed the failure rate of all-inside meniscal repair and noted a similar trend.

Different methods of assessing meniscal repair healing have been reported, including clinical, second-look arthroscopy, and magnetic resonance imaging (MRI). Miao et al.²⁴ recently compared these techniques and found that strict clinical evaluation resulted in lower estimates of the healing rate compared with MRI or second-look arthroscopy. A thorough clinical evaluation including history and physical examination remains the gold standard, and this may be supplemented with imaging studies when needed. Clinical failure requiring reoperation remains the most feasible basis on which to assess long-term outcomes of meniscal repair. In addition to reoperation, the definition of failure in the present study included clear evidence of clinical failure (generally mechanical symptoms). None of the included studies focused on the rate of failure assessed with use of second-look arthroscopy or MRI imaging.

Several studies have previously suggested a higher failure rate for medial compared with lateral meniscal repair^{14,18}. We found four studies with a higher failure rate for medial meniscal repair and three studies with a higher failure rate for lateral meniscal repair. Overall, there was a small difference in the pooled failure rate between medial (24.2%) and lateral (20.2%) meniscal repairs. However, the results of the included studies were fairly heterogeneous and the actual difference in the failure rate was relatively small (Fig. 1).

ACL reconstruction has traditionally been thought, on the basis of the results of short-term studies, to be associated

with a higher rate of successful meniscal healing compared with ACL-deficient²⁵⁻²⁷ and ACL-intact knees^{26,28-31}. This has been hypothesized to be due to the increased blood in the joint associated with the surgically induced hemarthrosis and the more peripheral and vertical orientation of meniscal tears associated with ACL injuries³². However, in our systematic review of the medium to long-term outcomes of meniscal repair, ACL reconstruction was not associated with a lower failure rate. The failure rate was 22.7% in the eight studies (nine groups) reporting on meniscal repairs in ACL-intact knees compared with 26.9% in the three studies reporting on repairs (inside-out or all-inside) in ACL-reconstructed knees. However, our study may have had inadequate power to detect a difference between these subgroups. The number of studies reporting on long-term outcomes of meniscal repair combined with ACL reconstruction was somewhat limited, as older studies often included knees treated with ACL repair or extra-articular augmentation. Several recent studies have failed to demonstrate the benefit of ACL reconstruction on meniscal healing at medium to long-term time points^{10,18}. However, in one study¹⁰, this may be attributed to the poor outcome of the all-inside repair device used. Our study failed to demonstrate improved rates of meniscal repair healing at greater than five years postoperatively.

Rehabilitation protocols after meniscal repair can vary from non-weight-bearing immobilization to full weight-bearing and immediate knee motion. Historically, open meniscal repairs were generally immobilized and treated with non-weight-bearing. More aggressive approaches now utilize various degrees of weight-bearing and knee motion postoperatively. Current approaches to rehabilitation after meniscal repair vary widely and generally rely on surgeon preference. The pooled rate of failure was relatively similar for non-weight-bearing protocols (25.7%) and partial weight-bearing protocols (21.7%). Only a single study allowed full weight-bearing. The pooled rate of failure did not differ between protocols utilizing immobilization (23.7%) and early knee motion (22.7%).


The rate of meniscal repair failure at greater than five years was relatively consistent in the included studies (16.0% to 29.0%), with the exception of the study by Steenbrugge et al.²² That study reported no failures among twenty inside-out repairs and a 4.0% rate of failure among twenty-five all-inside repairs. The authors documented ten patients lost to follow-up, all from the all-inside group. The authors documented variable tear locations relative to the periphery of the meniscus, including several white-white tears. Detailed information on the extent of clinical follow-up was not provided. Although the patient population, selection of tears to repair, operative

technique, and indications for reoperation likely influence the rate of repair failure, the reason for such a large difference between that study and all other studies is unclear.

The present study has several limitations. The quality of a systematic literature review is dependent on the individual studies. The amount of detailed information on the characteristics of subgroup populations was highly variable among the included studies. When possible, the authors of the included studies were contacted to provide missing information, although such information was not always recoverable. There was inherent heterogeneity in the patient population, meniscal tear configurations, surgical technique, and postoperative rehabilitation among the included studies. However, this systematic review summarized the currently available literature on the medium to long-term outcomes of meniscal repair, and in some cases the results contradicted findings at earlier time points.

In summary, the outcomes of meniscal repair at greater than five years postoperatively demonstrated very similar rates of meniscal failure (22.3% to 24.3%) for all techniques. No outcomes of meniscal repair at greater than five years postoperatively have been reported for modern all-inside devices. At long-term follow-up, no significant difference in the rate of meniscal repair failure was seen for ACL-intact compared with ACL-deficient or ACL-reconstructed knees, and a small difference suggesting a higher failure rate for medial compared with lateral meniscal repair was observed.

Appendix

 Tables summarizing the characteristics of the included studies are available with the online version of this article as a data supplement at jbjs.org. ■

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