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A Systematic Review of Outcomes

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Background: Loss of meniscal tissue in the pediatric population can have long-term consequences on joint health, highlighting the importance of meniscal preservation in this group.

Purpose: To systematically review reported knee outcome measures and complication rates after repair of meniscal tears in children and adolescents.

Study Design: Systematic review; Level of evidence, 4.

Methods: A review of the literature regarding the existing evidence for pediatric meniscal tear outcomes was performed through use of the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed (1980-present), and MEDLINE (1980-present). Included were articles in English that reported the outcomes of meniscal tears in the pediatric population (<18 years old) with a follow-up of more than 12 months. Clinical outcome scores were reviewed.

Results: A total of 1003 total studies were initially retrieved, with 8 meeting the inclusion criteria. The review included 287 patients (165 male, 122 female), mean age 15.1 years (range, 4-18 years), with 301 meniscal tears (reported: 134 medial, 127 lateral, and 32 both medial and lateral, 8 location unspecified). Concomitant anterior cruciate ligament reconstruction was performed in 52% (158/301) of meniscal repairs. The average reported postoperative Lysholm scores ranged from 85.4 to 96.3, and the average reported postoperative Tegner activity scores ranged from 6.2 to 8.

Conclusion: Arthroscopic repair of a meniscal tear in the pediatric and adolescent population is an effective treatment option that has a low failure rate, enhances postoperative clinical outcomes, and preserves meniscal tissues.

Keywords: pediatrics; meniscus; meniscal tear; meniscal repair; sports medicine; arthroscopy

The meniscus is an important cartilaginous structure within the knee, providing shock absorption,[23] resilience to compression,[19] stabilization,[23] and optimization of weight distribution by increasing contact surface area.[23] Furthermore, the meniscus contributes to proprioception,[28] nutrition of articular cartilage,[20] and joint lubrication.[8] Changes in meniscal structure, such as discoid meniscus or meniscal tears, alter normal knee biomechanics and may increase the incidence of other injuries within the knee.[16,27] Many studies have shown that a loss of normal meniscal function increases the rate of degenerative changes, leading to early-onset osteoarthritis, pain, and lower quality of life.[3,10,18,19,21] Consequently, loss of meniscal tissue in the pediatric population has been demonstrated to have long-term consequences on joint health, highlighting the importance of meniscal preservation in this group.[7,14]

Limited data have been published on the epidemiological patterns and treatment strategies for meniscal tears in children and adolescents. Although consensus may exist on the operative indications, variability remains regarding surgical technique and/or postoperative management. This is particularly true in the setting of meniscal repair in the young and active population.[2] Furthermore, the increasing number of reported knee injuries in adolescents and children[2,10] calls for improved understanding of the best modalities to treat these injuries along with the expected outcomes. The purpose of this study was to systematically review reported knee outcome measures and complication rates after repair of meniscal tears in children and adolescents. It was hypothesized that repair of pediatric meniscal tears (age <18 years) will result in improved clinical outcome scores, demonstrating the importance of meniscal preservation.

METHODS

Article Identification and Selection

This study was conducted in accordance with the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (registration No.

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CRD42017077140). A systematic review of the literature regarding the existing evidence for outcomes of pediatric meniscal tears was performed through use of the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed (1980 to present), and MEDLINE (1980 to present). The queries were performed in March 2018.

The literature search strategy included the following search: "(pediatric OR adolescent OR children) and meniscus AND tear." Included were articles in English that reported the outcomes of meniscal tears in the pediatric population (age <18 years) with a follow-up longer than 12 months. Publications were excluded if they involved cadaveric studies, animal studies, basic science articles, editorial articles, or surveys. All references within the included studies were cross-referenced for inclusion if missed by the initial search. If a duplicate study population was encountered, the article with the longer mean follow-up was included to avoid overlap.

The abstracts from all identified articles were independently reviewed by 2 investigators (D.J.L., D.S.C.). Full-text articles were obtained for review if necessary, to allow further assessment of inclusion and exclusion criteria. Additionally, all references from the included studies were reviewed and reconciled to verify that no relevant articles were missing from the systematic review.

Literature Quality Evaluation

The risk of bias and the methodological quality of the included studies were assessed by use of the modified Detsky Quality Assessment score.[5] Because this score was initially developed for randomized trials, an extra item was added to assess the comparability of the cohorts on the basis of study design and/or analysis. The total possible score was 21. A study with a score more than 75% of the total was considered high quality.[4,5] Any disagreements between the 2 reviewers were resolved through discussion.

Bias

Studies classified as level of evidence 3 or 4 can potentially be affected by selection and performance bias because of the lack of randomization and prospective comparative control groups (level 4), especially in populations characterized by heterogeneity of injuries. Selected studies were reviewed for potential bias, although the constraints present within such studies were recognized. Given the anticipated heterogeneity, the results were presented individually, and no quantitative synthesis of data was performed.

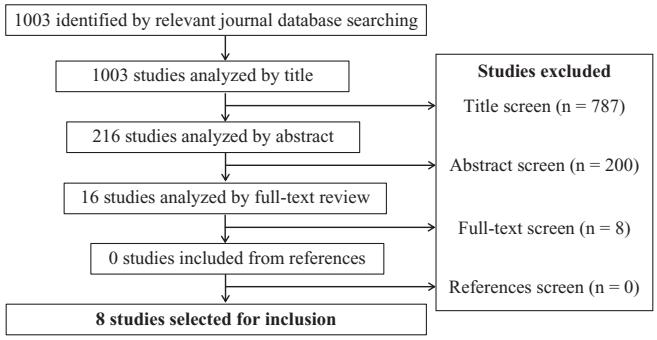

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram. Search and selection criteria for systematic review of pediatric patient outcomes following operative management of meniscal repair.

Data Collection

The level of evidence of the studies was assigned according to the classification as specified by Wright et al.[26] The information was collected from the included studies. Patient demographics, follow-up, and objective and subjective outcomes were extracted and recorded. For continuous variables (eg, age, timing, follow-up, outcome scores), the mean and range were collected if reported. Data were recorded into a custom Microsoft Excel spreadsheet by use of a modified information extraction table.

RESULTS

Study Selection

Initially, 1003 articles were identified from the MEDLINE database. No additional articles were identified from the Cochrane database. Each article was first screened by title, leaving 216 articles. The remaining articles were then screened by abstract and, if necessary, full text, yielding 16 articles. After full-text review, 8 studies[1,11-13,15,17,22,24] met criteria and were included in the review. All 8 included studies were retrospective reviews or case series (evidence level 4). Figure 1 is a PRISMA flowchart that demonstrates selection criteria of the systematic review. A review of all

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TABLE 1
Study Design, Patient Demographics, and Outcomes of the Included Pediatric Meniscal Repair Studies[a]

Lead Author	Study Design	Technique	No. of Patients (Menisci)	Sex	Mean Age, y (range)	Mean Follow-up (range)	Time From Injury to Surgery	Outcome Measures
Lucas[15]	Case series	1 outside-in 17 all-inside 1 abrasion	17 (19)	9 M 8 F	14 (9-18)	22.3 mo (3.5-46 mo)	5.3 mo	Lysholm, Tegner, MRI
Mintzer[17]	Case series	25 inside-out 4 all-inside	26 (29)	12 M 14 F	15.3 (11-17)	5.0 y (2-13.5 y)	6.7 mo	IKDC, Lysholm, SF-36
Kraus[11]	Case series	25 all-inside 4 outside-in	25 (29)	13 M 12 F	15 (4-17)	2.3 y (1.2-5.1 y)	Not reported	Lysholm, Tegner
Vanderhave[24]	Case series	Inside-out for all	45 (49)	31 M 14 F	13.2 (9-17)	27 mo (17-52 mo)	88 d	IKDC, Tegner
Accadbled[1]	Case series	4 all-inside 4 outside-in 2 additional open arthrotomy 1 inside-out 1 abrasion	12 (12)	7 M 5 F	13 (8-16)	37 mo (24-58 mo)	7 mo	IKDC, Lysholm, Tegner, MRI, SF-36
Krych[12]	Case series	17 inside-out 13 hybrid 15 all-inside	44 (45)	38 M 6 F	15.8 (9.9-18.7)	5.8 y (2.5 mo to 13.8 y)	69 d for the successfully repaired menisci 77 d for failed initial repair	IKDC, Tegner
Schmitt[22]	Retrospective study	19 all-inside meniscal	19 (19)	12 M 7 F	14.8 (9.1-16.3)	6.1 y (3-9 y)	Not reported	IKDC, Lysholm, Tegner, KOOS
Krych[13]	Case series	29 inside-out 64 all-inside 6 hybrid	99 (99)	43 M 56 F	16 (13-18)	8 y (2-19 y)	107 d	Tegner, IKDC

[a]All studies were level 4 evidence. F, female; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; M, male; MRI, magnetic resonance imaging; SF-36, 36-Item Short Form Health Survey.

references from the included studies did not yield any additional studies that met the inclusion criteria.

Patient Demographics

In this review, a total of 287 patients (301 menisci) were included, with study sizes ranging from 12 patients (12 menisci) to 99 patients (99 menisci). Overall, there were more males than females (165 vs 122, respectively). The mean age of patients in the included studies was 15.1 years (range, 4-18 years). Average patient follow-up in the included studies was 51.6 months (range, 22.3-96 months). All studies reported on the laterality of meniscal tears (Table 1).

Meniscal Tears

A variety of tear locations and patterns were reported and are detailed in Table 2. Additionally, Krych et al[12] measured the distance of the tear from the meniscal-synovial junction, with 15 tears being measured within 3 mm and 30 tears greater than 3 mm. Tear pattern was variably reported, with a predominance of complex and bucket-handle tears.

Literature Quality Assessment

All 8 of the included studies were retrospective case series, consisting of level IV evidence. No comparable intervention group exists within these studies. Therefore, an inherently high level of bias is present for all 8 studies.

Repair Techniques

Menisci were most commonly repaired with either inside-out or all-inside techniques, although Accadbled et al[1] and Krych et al[12] reported the use of outside-in or hybrid techniques (Table 1). Accadbled et al[1] reported that an additional open arthrotomy was required in 2 cases. The use of abrasion and perforation was infrequently reported.

Outcomes

Outcome scores that were measured included the Tegner score, Lysholm score, 36-Item Short Form Health Survey, International Knee Documentation Committee (IKDC) score, and need for repeat surgery. With regard to surgical outcomes, a variety of subjective and objective outcomes were reported (Table 3). The average postoperative Lysholm scores were reported in 5 studies and ranged from

TABLE 2
Meniscal Tears and Surgical Procedures in the Included Pediatric Meniscal Repair Studies[a]

Lead Author	Tear Location	Tear Zone[b]	Concomitant Injury	Concomitant Procedures
Lucas[15]	10 M, 9 L 10 left, 9 right	3 RR 16 RW	Isolated	Isolated
Mintzer[17]	9 M, 14 L, 3 both M&L 14 left, 12 right	22 RR 6 RW 1 WW	15 ACL tears (13 LM, 2 MM), 1 tibial plateau fracture	15 simultaneous ACL reconstructions
Kraus[11]	16 M, 10 L 12 left, 13 right	8 RR 11 RW 5 WW	13 ACL tears (6 MM, 4 LM, 3 BM)	11 simultaneous ACL reconstructions, 2 delayed ACL reconstructions
Vanderhave[24]	17 M, 28 L, 4 both M&L 30 left, 19 right	7 RR 33 RW 9 WW	31 ACL tears (11 MM, 16 LM, 4 BM)	31 ACL reconstructions
Accadbled[1]	4 M, 8 L 2 left, 10 right	6 RR 3 RW 3 MSJ	3 ACL tears, 1 ACL deficient	2 simultaneous ACL reconstructions, 1 delayed ACL reconstruction
Krych[12]	25 M, 20 L 24 left, 21 right	NR	None	None
Schmitt[22]	5 M, 12 L 8 left, 11 right	NR	11 ACL tears	4 Kenneth-Jones arthroscopic ligamentoplasty procedures, 7 Clocheville ligamentoplasty procedures
Krych[13]	48 M, 26 L, 25 both M&L Left/right: NR	NR	All 99 patients had concurrent ACL tears	ACL reconstruction

[a]ACL, anterior cruciate ligament; BM, both medial and lateral meniscus; L, lateral; LM, lateral meniscus;; M, medial; MM, medial meniscus; NR, not reported.
[b]Zones are classified as red (vascular) and white (avascular). RR, red, red; RW, red, white; WW, white, white; MSJ, menisco-synovial.

TABLE 3
Knee Outcome Scores of the Included Pediatric Meniscal Repair Studies[a]

Lead Author	Tegner Before/After	Lysholm Before/After	SF-36 Before/After	IKDC Before/After	Return to Activity
Lucas[15]	3.9/7.1	55.8/85.4	NR/NR	NR/NR	NR
Mintzer[17]	NR/NR	NR/90	NR/76	22 level I 4 level II	24/26 patients returned. 2 had lower level of activity unrelated to symptoms.
Kraus[11]	7.8/7.2	NR/95	NR/NR	NR/NR	NR
Vanderhave[24]	NR/8	NR/NR	NR/NR	27 level I 13 level II	NR
Accadbled[1]	6.9/6.6	65.3/96.3	NR/NR	9 level A 3 level B	10/12 patients returned. 2 did not return to previous level.
Krych[12]	NR/8	NR/NR	NR/NR	65.1/89.4	NR
Schmitt[22]	7.6/7.3	NR/95.7	NR/NR	NR/90.7	11/19 patients returned. 2 improved, 6 deteriorated.
Krych[13]	1.9/6.2	NR/NR	NR/NR	48/90.3	NR

[a]Tegner (range, 0-10). Lysholm (range, 0-100). SF-36, 36-Item Short Form Health Survey (range, 0-100). IKDC, International Knee Documentation Committee (range, 0-100; level 1, participating in strenuous activities that include jumping, pivoting, and hard cutting; level 2, participating in moderate activities such as heavy manual work and sports such as skiing and tennis; level A, normal; level B, nearly normal). NR, not reported.

85.4 to 96.3. The average postoperative Tegner activity scores were reported in 7 studies and ranged from 6.2 to 8.

Complications and Revision Surgery

Surgical failure, as defined by need for revision surgery, was found in 5 of the 8 studies. A total of 52 failures in 301 total menisci were reported (17.3% failure rate) at a mean time of 16.6 months after initial surgery. Of these, 41 patients underwent partial meniscectomy at the time of revision surgery whereas 9 patients underwent re-repair. The remaining 2 patients opted for nonoperative management. In total, 2 complications were reported. Of these, 1 was a partial peroneal nerve palsy following an open lateral meniscal repair by

posterolateral arthrotomy that spontaneously recovered 4 months after surgery.[1] The second complication involved 1 patient who developed septic arthritis postoperatively and underwent incision and drainage and antibiotic treatment.[13]

Level of Evidence

Overall, the level of evidence on studies reporting outcomes after meniscal tears in the pediatric population was poor. Of the 8 studies analyzed, all had an evidence level of 4.

DISCUSSION

The most important finding of this review was that meniscal repair may be a successful surgical technique to manage meniscal tears in the pediatric and adolescent population. Meniscal repair can potentially diminish the risk of future degenerative joint changes. All studies included in this systematic review concluded that clinical postoperative scores of pediatric meniscal repair support its use as an acceptable surgical technique for meniscal tears.

This review of a total of 301 meniscal tears (134 medial, 127 lateral, 32 both medial and lateral, 8 location unspecified) demonstrated 172 concomitant anterior cruciate ligament (ACL) tears and 1 ACL-deficient knee in the included studies. When ACL injury occurred, the occurrence of meniscal tears was as follows: 37% lateral (59/158), 42% medial (67/158), and 21% bilateral (32/158). Delaying ACL reconstruction increased the frequency of meniscal tears.[9] Meniscal repair results were improved when concurrent with ACL reconstruction.[11,13] However, Vanderhave et al[24] noted that concurrent ACL reconstruction entailed significantly longer return to activity times and lower Tegner scores.

Meniscal tear zone was reported in 5 studies,[1,11,15,17,24] whereas the remaining studies did not specify a tear zone (see Table 2). Of the 8 studies reviewed, Krych et al[12,13] concluded there were differing clinical success rates across different meniscal tear patterns.

Results of arthroscopic meniscal repairs have proven to be favorable among the adult population.[6] However, the literature has not yet established consensus on optimal treatment for meniscal repairs in the pediatric and adolescent population. The rising incidence of knee injuries among this population highlights the importance of pursuing timely repair, as delaying time to surgery after a knee injury increases the risk of meniscal damage.[6,25] Ultimately, this systematic review emphasizes the effectiveness of treating pediatric and adolescent meniscal tears.

Outcome scores among studies varied, making objective conclusions difficult. Of the 5 studies that included pre- and postoperative Tegner scores,[1,11,13,15,22] only Lucas et al[15] and Krych et al[13] reported improvement. Although Kraus et al[11] did not find an improvement, they did report a high healing rate of 83%. Kraus et al,[11] Accadbled et al,[1] and Schmitt et al[22] reported average postoperative Lysholm scores of 95, 96.3, and 95.7, respectively, which are considered normal.

Pre- and postoperative Lysholm scores were included in 2 studies, and both showed improvement following meniscal repair.[1,15] Results on return to activity were included in 3 studies.[1,17,22] Mintzer et al[17] reported that 24 of 26 patients returned to their previous level of sport, with the remaining 2 patients providing reasons for nonreturn that were unrelated to meniscal surgery. Accadbled et al[1] reported that 2 of 12 patients did not return to their previous level of sport, although 1 of those patients had a near normal IKDC score.[1] Schmitt et al[22] reported that 11 of 19 patients returned to activity; of the remaining 8 patients, 2 patients had improvement of symptoms and 6 patients experienced deterioration with increased meniscal involvement.

Limitations

An important limitation of this study was the level of evidence of the included studies. All studies were level 4 evidence, consisting of retrospective reviews or case series. As a result, it is difficult to provide strong recommendations regarding the operative treatment of pediatric meniscal injuries. Although the mean follow-up was 51.6 months, the range was 2.5 months to 19 years. Without consistent data at 2-year follow-up, re-tear rates and other complications may have been missed. However, based upon the available literature, the present study is able to provide a reasonably complete analysis of the currently available outcomes following meniscal repair in a young population.

CONCLUSION

The available data suggest that arthroscopic repair of a meniscal tear in the pediatric population is an effective treatment option that has a low failure rate, provides good clinical outcomes, and preserves meniscal tissue. Future areas of research examining patient-reported outcomes and patient-reported outcome measures extending for a follow-up period into adulthood may allow for further insight into long-term success rates.

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