Systematic Review

Manipulation Under Anesthesia and Lysis of Adhesions Are the Most Commonly Reported Treatments for Arthrofibrosis of the Knee After Arthroscopy or Anterior Cruciate Ligament Reconstruction in Both Pediatric and Adult Patients

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Purpose: To systematically review the literature and provide a detailed summary of the current treatments and outcomes for arthrofibrosis following knee arthroscopy and anterior cruciate ligament reconstruction (ACLR) and to compare the treatment strategies in pediatric and adult populations. **Methods:** A systematic review was performed in March 2022 using PubMed, EMBASE, and Cochrane Library Databases per Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Search terms consisted of variations of the following: ("arthrofibrosis" OR "stiffness" OR "stiff" OR "complications") AND ("arthroscopy" OR "arthroscop" OR "ACL" OR "anterior cruciate") AND ("treat" OR "care" OR "management" AND "knee"). The inclusion criteria were studies that were written in English, were published since 2000, and that reported outcomes of knee arthroscopy or ACLR for treatment of arthrofibrosis of the knee. The study quality was assessed, and data about the patients and treatments were recorded. Treatments were compared between pediatric and adult patients. **Results:** A total of 1,208 articles were identified in the initial search, 42 (3.48%) of which met eligibility criteria, involving treatment regimens for arthrofibrosis following knee arthroscopy or ACLR. Of the 42 studies included, 29 (69.0%) were reported data for adults and 13 (31.0%) reported data for pediatric patients. Thirty-nine studies (92.8%) discussed manipulation under anesthesia and/or lysis of adhesions (LOA) as treatment for arthrofibrosis of the knee, whereas 2 (4.8%) described the use of medications. **Conclusions:** Within orthopaedic sports medicine literature, there is variability in the reported treatment options for arthrofibrosis of the knee. Most studies identified manipulation under anesthesia and/or LOA as the treatment among both adult and pediatric patients. Other variants include notchplasty, open posterior arthrolysis, total graft resection, removal of hardware with LOA, dynamic splinting, casting in extension, bracing, and medications. **Level of Evidence:** Level IV, systematic review of Level I-IV studies.

Arthrofibrosis is a common complication in most joints following orthopaedic surgical procedures such as arthroscopy, anterior cruciate ligament reconstruction (ACLR), and total joint replacement (total knee arthroplasty [TKA]).[1] ACLR has been identified to be commonly associated with the development of arthrofibrosis of the knee.[1,2] Consequently, patients of all ages can suffer from pain and decreased range of motion, which hinders their progress postoperatively, prevents them from performing activities of daily living, and, ultimately, affects their quality of life.[3,4] The definition of arthrofibrosis varies widely, as do the approaches for management of this condition. For example, some may define arthrofibrosis based on the loss of flexion and/or extension reported in degrees. Alternatively, arthrofibrosis may be defined based on the presence of scar tissue in compartment(s) of a joint.[4] More specifically, the knee is the most

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commonly affected joint, with arthrofibrosis occurring both post-trauma and postoperatively.[2] The importance of early rehabilitation and prevention of arthrofibrosis has been explored extensively, and conclusions have been drawn based on the index surgery performed.[5-8]

Previous studies have explored treatment strategies for arthrofibrosis after TKA. A systematic review providing a thorough, comprehensive review has been performed and identified arthrofibrosis following TKA can be improved with manipulation under anesthesia (MUA) and/or arthroscopic lysis of adhesions (LOA).[9] Although treatment strategies for arthrofibrosis following TKA have been explored, there are not extensive data exploring treatment options for arthrofibrosis of the knee following knee arthroscopy and ACLR, which are the most common among the general population.[9] We sought to focus on the most common etiologies associated with arthrofibrosis of the knee, taking into consideration that these are not the only etiologies that could lead to the development of arthrofibrosis. Other common etiologies include TKA, trauma, and multiligamentous injuries; these were not included in this study, as it would broaden the scope of the conclusions that could be drawn from this study. In addition, there are a variety of options available including but not limited to administration of medical management, MUA, arthroscopic LOA, etc. The purposes of this study were to systematically review the literature and provide a detailed summary of the current treatments and outcomes for arthrofibrosis following knee arthroscopy and ACLR and to compare the treatment strategies in pediatric and adult populations. We hypothesized that MUA and LOA would remain the most common treatment methodologies with favorable outcomes in the setting of arthrofibrosis following knee arthroscopy or ACLR in both the adult and pediatric populations.

Methods

Study Design

A systematic search of electronic databases was performed using PubMed, EMBASE, and Cochrane Library Database. The search was performed in March of 2022, in accordance with the most up to date PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify and collect articles describing treatment regimens for arthrofibrosis of the knee following arthroscopy and following ACLR.

Search Strategy

The following search terms were used to identify relevant studies: ("arthrofibrosis" OR "stiffness" OR "stiff" OR "complications") AND ("arthroscopy" OR "arthroscop" OR "ACL" OR "anterior cruciate") AND ("treat" OR "care" OR "management" AND "knee").

Eligibility Criteria

Studies were included if they met the following criteria: written in English, published between the year 2000 to present day, abstracts relating to knee arthroscopy surgical outcomes and ACLR outcomes, and abstracts referring to treatment for arthrofibrosis of the knee within the full text of the paper. The inclusion criteria aimed to capture outcomes status post medical, nonoperative, and operative treatment of arthrofibrosis following knee arthroscopy and/or ACLR. The search was not limited to a specific patient sex. To capture articles with relevant treatment, the search was limited to studies conducted in the United States or non-U.S. countries that offer the same treatment strategies available in the United States. Non-human studies, cadaveric studies, editorials, narrative reviews, systematic reviews, case reports, and published abstracts that did not have a corresponding full-text article were excluded. The remaining exclusion criteria were as follows: studies that discuss arthrofibrosis following TKA rather than knee arthroscopy or ACLR, studies that discuss arthrofibrosis following trauma to the knee that are not treated with arthroscopy or ACLR, and studies that do not include any outcomes.

Data Extraction and Assessment of Study Quality

Data were extracted concurrently by 2 reviewers (R.R. and C.B.) using the method as follows: 1 author (R.R.) independently performed the search; 2 authors independently removed duplicates, screened titles, and abstracts for relevance and screened the remaining full-text articles against the eligibility criteria discussed above. Relevant studies referenced by the eligible articles were identified and subsequently screened against the same eligibility criteria. Any discrepancies between reviewers were resolved by the senior author on the team (M.V.) to enhance objectivity to avoid remediable mistakes in this study, and to improve the overall quality of the study.

Once inclusion and exclusion were completed, data were extracted from each article independently by 2 members of the research team (R.R. and C.B.). Any disagreements were resolved by discussion. Unresolved disagreements were resolved by the senior author. Descriptive data were extracted from each article including article demographics, patient demographics, information about the index surgical procedure and treatment methods implemented, and follow-up. Outcome data for each procedure were reported in the following ways: objective examination findings (active and passive range of motion), outcome scores (International Knee Documentation Committee Subjective score, Western Ontario and McMaster Universities Arthritis Index, Lysholm score, Tegner score), and complications. These outcomes were then compared between pediatric and adult populations. Data compilation and comparison were performed manually using Excel (Microsoft, Redmond, WA).

To assess the quality of each study included, a systematic approach was used based on the level of evidence. Level I was assigned to all randomized controlled trials and systematic reviews. Cohort studies were considered Level II. All case–control studies were considered Level III. Case report and case series was considered Level IV; however, case reports were excluded, as previously mentioned in the eligibility criteria. To address the potential for bias, only Levels I through IV were included in the review to limit bias from lesser quality studies.

Results

Search Results

A total of 1,208 articles were identified in the initial search (776 PubMed, 402 Embase, 30 Cochrane Library) (Fig 1). Of these studies, 160 duplicates were removed, leaving 1,048 articles to screen. Following the title abstract screening, 935 studies (77.4%) were excluded, leaving 318 studies (26.3%). Of the 935 studies, 29 (3.10%) were specifically excluded for the reason that they did not report outcomes. Of these 318

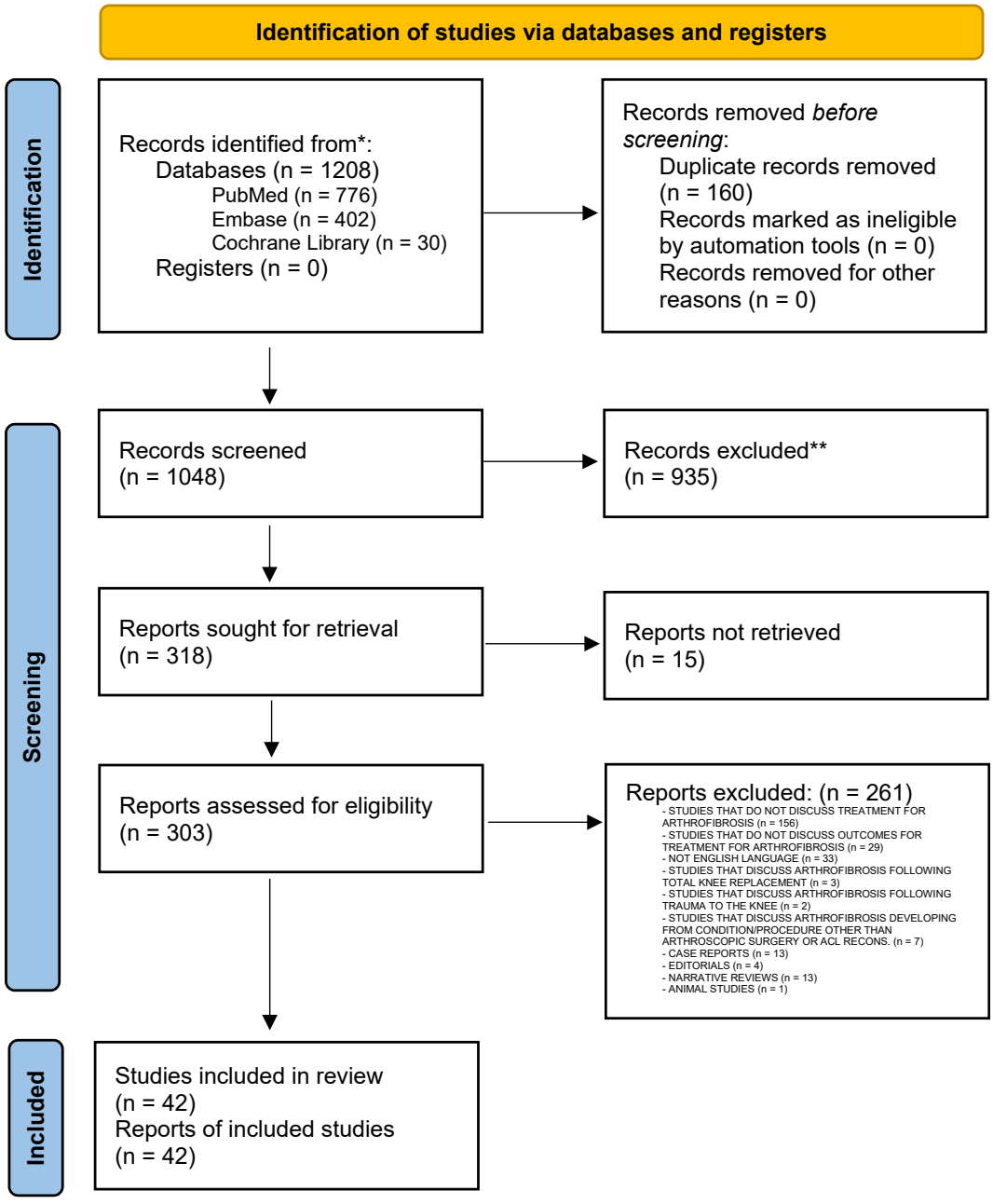

Fig 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

studies, 15 (4.72%) were excluded as the full text was unavailable. Based on the predetermined eligibility criteria, a total of 42 studies remained, which are summarized in Table 1.[2-4,9-26,27,28-32,33-47]

Treatment for Arthrofibrosis of the Knee in Adult Patients

Of the 42 included studies, 29[1-3,9-34] (69.0%) primarily focused on treatment for arthrofibrosis of the knee in adults. The index surgeries reported included ACLR (23 studies, 79.3%),[2,3,11-14,16,17,19-26,28-32,33,34] other arthroscopic ligamentous surgery (2 studies, 6.89%),[12,18] fixation of PCL avulsion fracture (1 study, 3.45%),[19] and fixation of tibial spine fracture (3 studies, 10.3%).[10,15,35] The most common treatments for arthrofibrosis were MUA and/or LOA (26 studies, 89.6%).[3,4,11-20,22-26,27,28-32,33,34,35] Notchplasty (1 study, 3.45%),[16] total graft resection (1 study, 3.45%),[21] open posterior arthrolysis (1 study, 3.45%),[33] casting or bracing in extension (2 studies, 6.89%),[22,27] and medications (2 studies, 6.89%)[4,27] were less commonly mentioned. Noyes et al.[27] described 2 patients who received continuous epidural anesthesia as a medical therapy, whereas Ekhtiari et al.[2] included 31 patients who received oral corticosteroids, epidural therapy in 6 patients, or intra-articular interleukin-1 antagonist injection in 4 patients. All patients included in these 2 studies[2,27] exhibited improvement in range of motion. The various treatments for arthrofibrosis for all included studies are summarized in Table 1 and clearly defined in Table 2.[3,6,10,12-20,22,23,25,27,28-32,33-35,46,48]

Comparing Treatment for Arthrofibrosis of the Knee in the Pediatric Population

Of the 42 included studies, 13 studies[4,36-47] (31.0%) focused on the treatment for arthrofibrosis following ACLR or arthroscopic surgery in the pediatric population, which was defined as a patient younger than the age of 18 years. Ten studies[4,29,36-38,40,42,45-47] (76.9%) described patients who underwent either MUA or LOA, whereas 5 studies[39-41,46,47] (38.5%) included patients who underwent both MUA and LOA for treatment. Less-common treatments for arthrofibrosis in the pediatric population were described in 4 studies[4,39,41,46] (30.8%), which included removal of hardware, notchplasty, bracing in extension, dynamic splinting. Six studies[4,37,39,41,43,47] (46.2%) mentioned complications resulting from treatment for arthrofibrosis of the knee. Among these 6 studies, 3 studies[4,41,43] (23.1%) reported motion deficit as the complication. The remaining 3 studies[37,39,47] (23.1%) reported the following complications: instability in the knee following LOA, requirement of revision surgery following MUA/LOA and extension brace, or distal femoral fracture following MUA with subsequent growth arrest requiring further treatment. The treatments for arthrofibrosis among the pediatric population are summarized in Table 3.[4,36-47]

Table 1. Summary of the 42 Included Studies

Treatment(s) for Arthrofibrosis	Studies
MUA only	14[2,4,9,18,27,29,30,32,33,36,38,40,44,45]
LOA only	23[3,4,9,11-14,16,17,22-25,27,28−32,35,37,42,45]
MUA and LOA	14[2,15,19,20,26,30−32,34,39,40,43,46,47]
Notchplasty	3[4,16,43]
Other surgical techniques	
Open posterior arthrolysis	1[33]
Total graft resection	1[21]
LOA and ROH	3[10,17,43]
Dynamic splinting	1[41]
Casting in extension	1[27]
Bracing	1[22]
Medications (e.g., oral corticosteroids, IL-1 antagonist injection, epidural therapy)	2[2,27]

IL-1, interleukin-1; LOA, lysis of adhesions; MUA, manipulation under anesthesia; ROH, removal of hardware.

Discussion

The most important finding of this study was that most studies identified MUA and/or LOA as the treatment for arthrofibrosis of the knee following arthroscopy or ACLR. There was substantial variability in the reported definitions of arthrofibrosis and/or the diagnostic criteria for arthrofibrosis of the knee. Although most of the studies included in our analysis described MUA and/or LOA as the most common treatment options for arthrofibrosis of the knee in both adult and pediatric patients, it is possible that the threshold to report arthrofibrosis and the subsequent treatment was based on how a paper defined arthrofibrosis. For example, arthrofibrosis could have been defined as a motion deficit requiring MUA and/or LUA. In addition, there is a spectrum of care that can be implemented based on the severity of arthrofibrosis of the knee, provider/institution knowledge or preference, resource availability, resulting in a wide variability in the specific treatment given, such as administration of medical management, MUA, LOA, etc., or even a combination of these treatments.

The secondary aim of this systematic was to compare the strategies in pediatric versus adult populations regarding the treatment for arthrofibrosis of the knee following ACLR or following arthroscopic surgery. Similar to the finding of the primary aim of the study, the most common treatments were MUA and/or LOA in the pediatric population. There was no mention of medication use among the pediatric population, whereas 2 studies[2,26] involving the adult population were identified to implement medication as treatment.

Table 2. Summary of Included Articles—Adult Population

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis (Number of Patients)	Outcomes	Complications
Mayr et al.,[3] 2004	IV	ACLR	LOA (223)	Mean ROM improved from 93.65° to 130.06°. 3.2% had >10° loss ROM after LOA.	In one case the original ACL graft was replaced.
Eckenrode et al.,[14] 2018	IV	ACLR	LOA (3)	Mean AROM improved from 122.7° to 128°. Mean pain rating improved from 2.7 to 0.7	None
Calloway et al.,[13] 2018	IV	ACLR	LOA, MUA (32)	IKDC scores improved from 49.6 to 69.4. WOMAC scores improved from 74 to 85.3	None
Robertson et al.,[30] 2009	III	ACLR	LOA (5)	Successful restoration of knee hyperextension with LOA.	None
Mayr et al.,[23] 2017	IV	ACLR	LOA (141)	Mean ROM improved from 99.47° to 127.98°. Mean pain rating was 1.34 with everyday life at 18.7 years' follow-up.	In 65% of cases, notchplasty was required. At 18.7 years after LOA, 56% and 38% of patients had abnormal or severely abnormal IKDC objective scores, respectively
Mauro et al.,[22] 2008	III	ACLR	LOA (28)	Following LOA, only 4 patients continued to have loss of ROM between 6° and 10°.	64.3% of patients with decreased ROM were noted to have reduced quadriceps tone and 46.4% had reduced patellar mobility.
Bodendorfer et al.,[12] 2019	III	ACLR, PCLR, LCLR	LOA (17)	Mean ROM improved by 38.8°. Mean KOOS composite score improved by 47.5 points following LOA. Mean WOMAC score improved by 50.5% postoperatively. Mean IKDC scores improved by 47.3 points postoperatively.	12 of 17 patients returned to preinjury level of activity. Of the 4 who did not fully return, one was a competitive athlete that was able to play recreationally. Another competitive athlete could only return to a minimal level of activity.
Thaunat et al.,[35] 2016	IV	Tibial spine avulsion fracture arthroscopic bone suture repair	LOA (1)	10° extension lag reduced to 3° extension lag	After anterior joint release, intraoperative assessment showed persistence of 10° deficit. Posterior release of joint capsule through 2 retro-ligamentous approaches was required.
Sanders et al.,[32] 2017	III	ACLR	MUA (4), MUA and LOA (19)	Mean ROM improved from 91° to 129°	None

(continued)

Table 2. Continued

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis (Number of Patients)	Outcomes	Complications
Hasan et al.,[16] 2000	III	ACLR	MUA and LOA (13)	Mean preoperative extension deficit improved from 10° to 3° following MUA and LOA. Passive knee flexion improved from 123° to 131° postoperatively. Mean postoperative Lysholm score was 89 and mHSS knee score was 90.	None
Worsham et al.,[34] 2019	III	ACLR	LOA (29)	Mean ROM deficit was 6.7° for extension and 19.8° for flexion. After LOA, ROM deficit was 3.5° for extension and 6.1° for flexion	None
Robertson et al.,[31] 2011	IV	ACLR	LOA (10), MUA and LOA (8)	14 patients experienced substantial improvement in knee extension with an average change of 6°. This left a mean extension deficit of 1°. Patients in the severe extension deficit group underwent LOA and MUA and showed mean improvement of 10°. 12 patients experienced substantial knee flexion improvement with an average change of 6°, leaving a mean flexion deficit of 2°. Patients in the severe flexion deficit group underwent LOA and MUA and showed mean improvement of 12°.	LOA was proven to be optimally performed within 8 months of the index procedure. LOA greater than >12 months after the index procedure had poorer outcomes.
Heusdens et al.,[17] 2020	II	ACL Repair	LOA and hardware removal (4)	"Regained natural knee movement"	None
Ibrahim et al.,[20] 2013	IV	ACLR, PCLR, and posterolateral corner reconstruction	MUA and LOA (4)	All patients improved their range of motion except one who had persistently >10° flexion deficit	None
LaPrade et al.,[19] 2019	IV	ACLR	MUA and LOA (18)	5 had knee extension deficits and 13 had flexion deficits	None
Panisset et al.,[28] 2017	IV	ACLR	MUA (2), LOA (4)	All knees were grade 1 flexion deficit at 1-year postoperatively. No extension deficits reported at 1-year postoperatively.	MUA for flexion deficit patients. LOA for extension deficit patients only.
Tardy et al.,[33] 2016	IV	ACLR	LOA (9), MUA, and LOA (3)	Mean ROM improved from 96° preoperatively to 143° postoperatively.	One patient had postop flexion deformity of 5°. One patient had ACL graft resected to achieve full extension.

(continued)

Table 2. Continued

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis (Number of Patients)	Outcomes	Complications
Noyes et al.,[27] 2000	II	ACLR with or without partial meniscectomy	LOA (3), MUA (9), extension casting (9)	In the extension casting group, all patients achieved at least 0° extension. In the MUA group, mean preoperative flexion was 92°. All MUA patients achieved at least 135° after intervention. LOA produced full ROM in all 3 patients.	None
Millett et al.,[6] 2004	IV	ACLR with concomitant MCL injury	LOA (1)	Following LOA, patient regained motion and function. Postoperative Lysholm and Tegner scores were 97 and 10, respectively.	None
Faivre et al.,[15] 2014	IV	Tibial spine fracture fixation with Tightrope device	MUA and LOA (2).	One patient had 10° flexion and 5° extension deficit. The other patient had full ROM	None
Prodromos et al.,[29] 2005	IV	ACLR	LOA and Hardware removal (1), MUA (1)	Full ROM following LOA. Full extension and nearly full flexion following MUA	None
Mariani,[48] 2010	IV	Tibial plateau and supracondylar femoral fracture ORIF	LOA (18)	Preoperative flexion and extension were 85° and 34°. Postoperative flexion and extension were 100° and 3°.	One patient developed synovial fistula at posterior portal site
Aderinto et al.,[10] 2008	III	Anterior tibial spine fixation	LOA and hardware removal (6), MUA (1)	LOA and hardware removal was successful in 2 of 6 cases. MUA resolved ROM limitations.	None
Meister et al.,[25] 2018	IV	ACL repair with dynamic intraligamentary stabilization	LOA (5)	No patient with LOA had normal ROM postoperatively. At 1-year follow-up, 2 patients had persistent extension deficit of 6-10° and 2 patients had >10°. A flexion deficit of 6-15° was present in 1 and 3-5° in another patient at 1-year follow-up.	3 patients complained about persistent VAS scores >3 at 1-year follow-up.

(continued)

Table 2. Continued

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis (Number of Patients)	Outcomes	Complications
Tibial Spine Research Group et al,[46] 2021	III	Type II tibial spine fractures	LOA and MUA (4), LOA (1), MUA (1), hardware removal alone (1), none (4)	6 patients had full ROM, 3 had functional ROM, and 2 had unknown final ROM. Patients treated with LOA and MUA had mean ROMs of 122.5°. The patient treated with LOA had 140° ROM. The patient with hardware removal had 140° ROM. Patients with no treatment had a mean ROM of 102.5°.	None
Lamoria et al.,[18] 2020	IV	Isolated tibial spine avulsion fractures	MUA (3)	One patient ended with 110° of flexion and 2 ended with 120° of flexion at final follow-up.	None

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; AROM, active range of motion; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; LCLR, lateral collateral ligament; LOA, lysis of adhesions; MCL, medial collateral ligament; mHSS, modified Hospital for Special Surgery; MUA, manipulation under anesthesia; ORIF, open reduction and internal fixation; PCLR, posterior cruciate ligament reconstruction; ROM, range of motion; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

This included oral corticosteroids, epidural therapy, and intra-articular interleukin-1 antagonist injection. Among both the pediatric and adult populations, most studies identified MUA and/or LOA as the treatment. Other variants include notchplasty, open posterior arthrolysis, other surgical techniques, dynamic splinting, casting in extension, and bracing. Future studies should aim to focus on other etiologies that could precede the development of arthrofibrosis of the knee such as trauma, multiligamentous injury, etc. In addition, future studies should aim to focus on the medications used in the treatment for arthrofibrosis of the knee and analyze clinical efficacy of each of these treatments. These future studies can aid in ultimately formulating an algorithm in the treatment for arthrofibrosis, with the goal of ultimately improving patient outcomes and quality of life.

Limitations

This study is not without limitations. As mentioned previously, there was a wide variety of definitions and/or diagnostic criteria for arthrofibrosis of the knee, which poses an inherent challenge of variation in the diagnosis of arthrofibrosis. Taking into consideration this is a systematic review, abstracts are solely searched for the defined terms as outlined in the Methods section. There may have been other studies that could have represented additional treatments for arthrofibrosis that may have not been captured in the full-text articles that were included in this review based on the predetermined eligibility criteria.

Conclusions

Within orthopaedic sports medicine literature, there is variability in the reported treatment options for arthrofibrosis of the knee. Most studies identified MUA and/or LOA as the treatment among both adult and pediatric patients. Other variants include notchplasty, open posterior arthrolysis, total graft resection, removal of hardware with LOA, dynamic splinting, casting in extension, bracing, and medications.

Disclosure

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: M.K.M. reports personal fees from Arthrex, outside the submitted work; American Academy of Orthopaedic Surgeons, American Orthopaedic Association, American Orthopaedic Society for Sports Medicine, Arthroscopy Association of North American, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine, Ruth Jackson Orthopaedic Society, and The Forum: board or committee member; and *American Journal of Sports Medicine-Electronic Media*, *Arthroscopy*, and *Ortho Info*: editorial or governing board. B.G.V.

Table 3. Summary of Included Articles—Pediatric Population

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis	Outcomes	Complications
May et al.,[40] 2011	IV	ARIF for ACL tibial spine avulsion	MUA and LOA; arthroscopic scar debridement; MUA	Satisfactory functional and clinical outcomes	None mentioned
Cruz, Jr. et al.,[38] 2017	IV	All-epiphyseal ACLR	MUA	Statistically significant increase in knee ROM	None mentioned
Nwachukwu et al.,[4] 2011	IV	ACLR	MUA; LOA; lateral release; notchplasty; debridement of scar tissue	86.8% of patients had full ROM. 13.2% had reduced ROM (extension deficits and/or flexion deficits)	Persistent motion deficits in 13.2% of patients
Pace et al.,[41] 2018	IV	ACLR with or without meniscal repair; surgical fixation of tibial spine fracture	DS; DS, MUA, and surgical LOA	84% treated with DS had improvement and 58% of all patients in the study avoided surgery as a result of DS treatment	23% of patients had extension deficit, 31% had flexion deficit, and 46% had combined extension and flexion deficits
Parikh et al.,[43] 2014	III	Arthroscopic reduction and screw fixation for displaced Type II and III tibial spine fractures	SR, debridement if epiphyseal screw; SR, notchplasty if extension deficit; SR, MUA for flexion deficit	80% of patients achieved 0° of final loss of motion	1 patient had a 15° extension deficit; 1 patient had a 2° extension deficit, but this patient did not undergo treatment other than screw removal
Fabricant et al.,[39] 2018	II	ACLR; tibial spine arthroscopic reduction and internal fixation, soft-tissue repair, and multiligament reconstruction	LOA/MUA with patient placed in hinged knee brace locked in extension postoperatively for sleeping and walking	62.2% reached full ROM, 27.8% reached functional ROM	10% of patients required revision surgery
Bram et al.,[36] 2019	III	ACLR with or without continuous passive motion (CPM)	MUA	Required more PT sessions compared with those that did not undergo MUA	None reported
Çağlar et al.,[37] 2021	IV	Arthroscopic suture fixation technique secondary to type 2, 3, or 4 tibial spine fracture	Arthroscopic synovium debridement	Knee flexion improved from 30° flexion contracture secondary to arthrofibrosis to 10° final flexion contracture	Instability noted in the knee, but patient did not have clinical complaints
Su et al.,[45] 2018	III	ACLR	MUA or LOA	Mean knee flexion of 134° achieved and full knee extension	None reported
Sankar et al.,[44] 2006	III	ACLR	MUA	No significant difference in Lysholm scores or report to sport	None reported
Pandey et al.,[42] 2017	III	Arthroscopic reduction and fixation of tibial spine avulsion using high strength nonabsorbable sutures	Arthroscopic adhesiolysis	No flexion or extension deficit	None reported
Tibial Spine Research Group et al.,[46] 2021	III	Surgery for tibial spine fractures	LOA and/or MUA; LOA and ROH; LOA, MUA, ROH	6 patients achieved full ROM, 3 had functional ROM, and 2 had unknown ROM results	None reported

(continued)

Table 3. Continued

Article	Level of Evidence	Index Surgery	Treatment(s) for Arthrofibrosis	Outcomes	Complications
Vander Have et al.,[47] 2010	IV	Surgical fixation of tibial eminence fracture	MUA; LOA and MUA; 1 + LOA	90.6% achieved near full ROM within 5° of the contralateral side, 9.4% lacked full extension	In 3 patients, MUA resulted in distal femoral fractures and subsequent growth arrest, requiring further treatment

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament rehabilitation; ARIF, arthroscopic reduction internal fixation; DS, dynamic splinting; LOA, lysis of adhesions; MUA, manipulation under anesthesia; PT, physical therapy; ROH, removal of hardware; ROM, range of motion; SR, screw removal.

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