Nonoperative Management, Repair, or Reconstruction of the Medial Collateral Ligament in Combined Anterior Cruciate and Medial Collateral Ligament Injuries—Which Is Best?

PODCAST In-Depth CME

A Systematic Review and Meta-analysis

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Background: Combined injury of the anterior cruciate ligament (ACL) and the medial collateral ligament (MCL) is a common injury pattern and accounts for 20% of all ligamentous knee injuries. Despite advancements in surgical technique, there is no up-to-date consensus regarding the superiority of nonoperative versus operative management in higher-grade MCL tears of combined ACL-MCL injuries.

Purpose: To interpret recent literature on treatment options and to provide an updated evidence-based approach for management of combined ACL-MCL knee injuries.

Study Design: Systematic review and meta-analysis; Level of evidence, 4.

Methods: We performed a systematic review on outcomes following treatment of concomitant ACL and MCL injuries. A computerized search was conducted in PubMed, Embase.com, and Scopus.com. Authors independently assessed eligible studies and screened titles and abstracts. Articles reporting on patients with concomitant ACL and MCL injuries with or without concomitant procedures were included. Data regarding study design, sample size, patient age and sex, length of follow-up, timing of surgery, indications, surgical methods, concomitant procedures, outcomes, and complications were recorded. Patient-reported outcomes (PROs) and functional outcomes, including Knee injury and Osteoarthritis Outcome Score, International Knee Documentation Committee scores, Lysholm and Tegner scores, and range of motion, were estimated via meta-analysis and compared statistically by surgical approach.

Results: In total, 18 studies were included in the systematic review with level 1 to level 4 evidence, with a total of 1,534 cases, were included in the systematic review. Of these, 16 studies with sufficient statistical reporting including 997 cases with sufficient follow-up were included in meta-analysis. Three different approaches to combined ACL-MCL injuries were identified: ACL reconstruction with (1) nonoperative MCL, (2) MCL repair, and (3) MCL reconstruction. There was no statistical difference between nonoperative versus surgically managed MCL injuries for PROs, range of motion at final follow up, or quadriceps strength.

Conclusion: Reconstruction of combined injury in a delayed fashion facilitates return of range of motion and may allow time for low-grade MCL tears to heal. If residual valgus or anteromedial rotatory laxity remains after a period of rehabilitation, then concomitant surgical management of ACL and MCL injuries is warranted. Avulsion MCL injuries and Stener-type lesions may benefit from early repair techniques.

Keywords: knee; ligaments; knee ligaments; ACL; MCL

A combined injury of the anterior cruciate ligament (ACL) and the medial collateral ligament (MCL) is a common knee injury and accounts for 20% of all ligamentous injuries.[33] In the athletic population, grade I and II MCL tears may present in isolation or with a concomitant ACL tear, whereas 95% of grade III MCL lesions are

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accompanied by concomitant ACL tears.[15] Traditional treatment of combined ACL-MCL injury is surgical reconstruction of the ACL and nonoperative management of associated grade I MCL tears.[6,20,32,47] Similarly, grade III MCL tears with distal MCL avulsion and pes anserinus interposition ("Stener" lesions) are indicated for repair at the time of ACL reconstruction.[12,31] However, there is otherwise a lack of up-to-date consensus regarding the superiority of nonoperative versus operative management in grade II and grade III MCL tears of combined ACL-MCL injuries.

Nonoperative MCL management in ACL-MCL combined ligamentous injuries is favored based on results of previous literature from the 1980s and 1990s that demonstrated exceptional healing potential of the MCL, in part due to its extra-articular anatomy.[4,23,35,52] Furthermore, nonoperative management of the MCL was favored due to concerns of lower rates of arthrofibrosis and reduced range of motion (ROM) after operative MCL management with repair or reconstruction.[36,40,45] However, there may be a greater risk of persistent valgus instability and rotational laxity with nonoperative management of the MCL compared with operative options.[1,26,53] Residual valgus laxity is believed to cause increased stress on the reconstructed ACL, therefore predisposing the graft to attenuation and failure.[1,26,53] These findings have led to the development of MCL repair and reconstructive techniques to restore stability while limiting effects on ROM and arthrofibrosis. Modern methods encompass minimally invasive techniques such as suture anchors, synthetic suture tapes, incorporation of the posterior oblique ligament (POL) and MCL, and reconstructive methods such as anatomic and triangular ligament reconstruction with interference screws, buttons, or staples.[¶]

Despite the extensive investigation into the management of combined ACL and MCL tears, decision-making regarding repair or reconstruction of high-grade MCL tears remains controversial. Moreover, there is a paucity of reviews reflective of contemporary operative techniques and their relative outcomes.[17,39] The purpose of this systematic review and meta-analysis was to identify and evaluate common management strategies for combined ACL-MCL injuries and provide an updated evidence-based approach for management of combined ACL-MCL injuries of the knee based on the evidence provided in our review.

[¶]References 5, 8, 10, 14, 28, 43, 49, 51, 55.

METHODS

Study Design

A systematic review was performed on the outcomes after concomitant anterior cruciate and medial collateral ligament injuries. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed to evaluate and assess study methodology. Outcomes from studies included in the systematic review were analyzed via meta-analysis.

Search Strategy

A systematic, computerized search of the literature in PubMed, Embase.com, and Scopus.com was conducted with controlled vocabulary and keywords related to ACL and MCL injuries. The vocabulary included *medial collateral ligament*, *repair*, *reconstruction*, *nonoperative*, *nonsurgical*, and *anterior cruciate ligament*. In addition, both acute (<6 weeks between injury and surgery) and chronic (>6 weeks) MCL grade II and III lesions were included. The search time frame was restricted to 15 years before the date of search, August 29, 2021. The search excluded posters, abstracts, and conference proceedings. The reference lists of all selected publications were checked to retrieve relevant publications that were not identified in the computerized search. Manuscripts published by the same authors were carefully reviewed to ensure included patients were not from overlapping populations.

Eligibility Criteria

Original articles were included if (1) outcomes were reported for patients with concomitant ACL and MCL injuries with or without concomitant procedures for studies of all levels of evidence, (2) the full text was available in English, and (3) the study was published in a peer-reviewed journal. There was no minimum patient age for inclusion. Case reports, systematic reviews, imaging reviews, animal studies, anatomic or histologic studies, surgical technical reports, and studies with <5 participants were excluded. For the meta-analysis, studies that did not report measures of spread (standard deviation, variance, range, or 95% CI) were excluded.

Study Selection

Three authors (K.A.-A., S.L., C.S.) independently assessed eligible studies identified by the search strategy. Titles and

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abstracts were screened by applying eligibility criteria, and full texts of potentially relevant studies were subsequently obtained. If the title and abstract did not provide adequate information to determine whether eligibility criteria were met, the study was included for full-text review. Full texts were then evaluated for relevancy according to inclusion and exclusion criteria. Two articles that met inclusion criteria had the same first author, Halinen[19] and Halinen.[18] These were evaluated in depth and were found to consist of the same cohort of patients, and thus duplicate results were not included in final analysis. The authors performed additional citation tracking by screening the reference lists of the eligible studies.

Data Extraction

Reviewers collected data in duplicate and recorded them in a customized database using an Excel spreadsheet (Version 2007; Microsoft). If data extraction disagreement was present, any continued disagreement was resolved by a third author (B.L.). Data regarding study design, sample size, patient age and sex, length of follow-up, timing of surgery, indications, surgical methods, concomitant procedures outcomes, and complications were recorded. Specific outcomes measured included patient-reported outcomes (PROs), ROM, strength, activity level, return to sport, and valgus or rotational laxity when available. Whenever outcomes were reported for more than 1 point in time during follow-up, values from the last recorded follow-up were used.

Quality Assessment

The level of evidence (levels 1 to 4) from the included studies was assessed by 3 reviewers independently (K.A.-A., C.S., S.L.) using the Oxford Center for Evidence Based Medicine guidelines. To further evaluate the study quality, the modified Coleman Methodology Score was used and scored for each study by 2 authors (S.L., K.A.-A.). Disagreements were resolved by a third author (N.M.).

Outcomes

Primary outcomes assessed via meta-analysis were PRO scores, including the Knee injury and Osteoarthritis Outcome Score (KOOS) with the following domains: Activities of Daily Living, Sport and Recreation, knee-related Quality of Life, Pain, and Symptoms (such as swelling and ROM deficits). Other outcome scores included the International Knee Documentation Committee (IKDC) score, the Tegner activity scale, and the Lysholm knee score.

Statistical Meta-analysis

After initial review, 3 major treatment strategies were identified: ACL reconstruction with (1) nonoperative MCL, (2) MCL repair, or (3) MCL reconstruction. The meta-analysis was performed using these 3 strategy groupings. Acute and chronic MCL tears were evaluated together.

To compare PROs between the 3 MCL treatment options (nonsurgical, repair, and reconstruction), a multitreatment meta-analysis was conducted. The mean and standard deviation from each study for each outcome specified above were analyzed. If a median and range were given instead, the mean and standard deviation were estimated using formulas from Hozo et al.[21] If the mean and 95% CI were given, the standard deviation was derived using the *t* statistic distribution.

Study characteristics were listed by study to compare cohorts and identify populations to which results can be generalized. Weighted means for descriptive statistics were calculated by multiplying the proportion of study patients to total patients included in the analysis by the mean value provided for patients in that study.

Heterogeneity of the studies was assumed; therefore, for each meta-analysis, an inverse, variance-weighted random-effects model was used. The estimated mean scores for each outcome and treatment group are presented with 95% CIs. In addition, forest plots are provided (Supplemental Figures 1-10) to visualize the treatment group differences for each outcome. Meta-analyses were conducted using SAS Version 9.4 (SAS Institute), and a P value <0.05 was considered statistically significant.

RESULTS

Search Strategy

A total of 2470 studies were identified in an initial exploration of database and reference searches. After duplicates were removed, a total of 895 titles and abstracts were screened. After review of titles and abstracts, 43 articles pertaining to concurrent ACL and MCL injuries were retrieved for full-text review. After full-text review, eligibility for inclusion in review was determined in 18 studies. Excluded articles included biomechanical cadaveric studies (n = 7), technique-based studies or case reports containing <5 patients (n = 5), review or commentary articles (n = 9), and studies on multiligamentous injuries involving more injuries than just the ACL and MCL (n = 4) (Figure 1). For meta-analysis, two additional studies were excluded due to insufficient statistical information provided, with a total of 16 studies included in analysis (Figure 1).

Three eligible patient groups were identified: combined ACL-MCL injury with ACL reconstruction and nonoperative treatment of MCL injury, combined ACL-MCL injury with ACL reconstruction and MCL repair, and ACL-MCL injury with combined ACL and MCL reconstruction.

Systematic Review Study Descriptions

Level of evidence, modified Coleman Methodology Score, study design, outcome measurements, and key findings for each study are reported in Table 1.

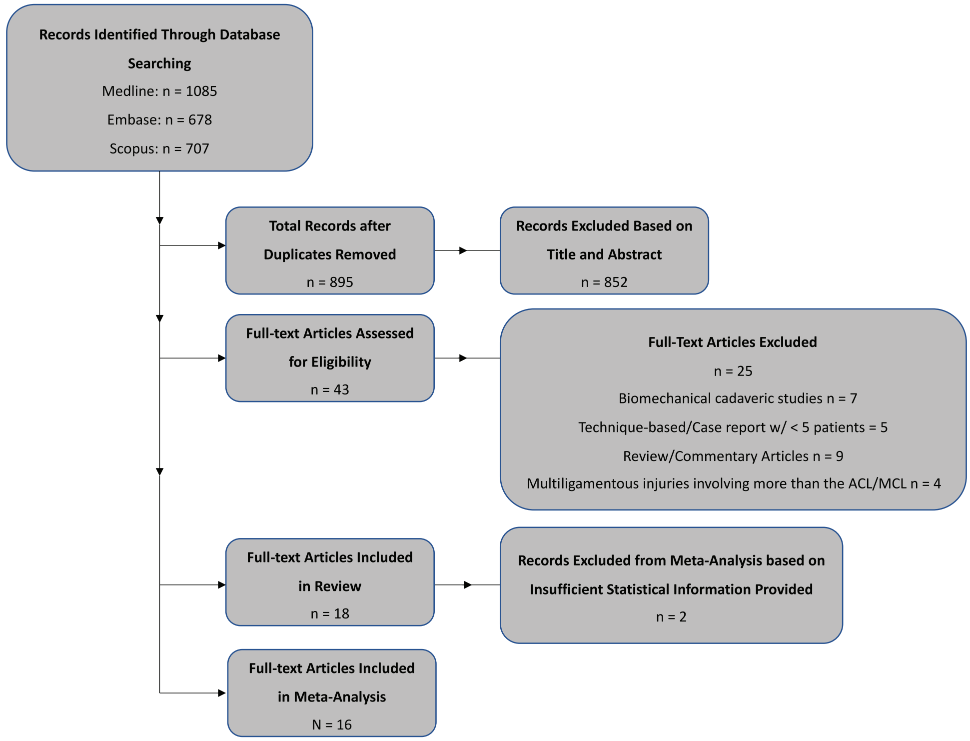

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

PROs of ACL Reconstruction With Nonsurgical Treatment of MCL, MCL Repair, and MCL Reconstruction: Quantitative Meta-analysis

Ultimately, of the 18 studies included in the systematic review, 2 (Westermann et al[51] and Millett et al[32]) were excluded from the meta-analysis due to insufficient reporting of a measure of spread (95% CI, range, or standard deviation). Thus, a total of 16 studies included in the meta-analysis. The two studies by Halinen et al.[18,19] referenced the same patient cohort, and while both studies were included, the total number of patients reflects the n of only one of these studies.

Descriptive Statistics. Individual summary statistics for studies included in the statistical meta-analysis can be found in Table 2. For all studies, the overall weighted mean age was 32.3 years. The weighted mean length of clinical follow-up was 23.3 months (range, 12-105 months), with 4 studies having <2 years of follow-up. The mean length of follow-up was not provided in the Kitamura et al[27] study, and those patients were therefore not included in the weighted mean follow-up calculation. Median study sample size was 27 cases (range, 12-287). The total number of cases was 997, with 10 of the final 16 studies having sample sizes of <50. For 12 of the studies, most patients were male (overall mean 65.3%).

Based on the quantitative meta-analysis, outcome scores did not differ between patients with an MCL injury treated nonsurgically, those who received MCL reconstruction, and those who received MCL repair at the time of latest follow-up (Table 3; Appendix Table A1, available in the online version of this article; Appendix Figures A1-A8, available online).

ROM was most frequently reported as percentage of patients who achieved normal or near-normal ROM at the time of final follow-up. Seven studies[10,13,14,19,27,37,46] reported on extension deficits, and 6 studies[14,19,27,37,38,46] reported on flexion deficits. There was no difference in number of patients who achieved normal or near-normal ROM between treatment groups (Table 3; Appendix Figures A9, A10, available online).

Return-to-play data were available for 4 studies and not sufficient for meta-analysis (Table 4). These studies included 2 examining nonsurgical treatment and 2 examining MCL repair. All patients who received nonsurgical MCL treatment in the Sankar et al[46] study returned to sport; however, 91% and 75% of participants in the Osti et al[37] and Canata et al[10] studies, respectively, who had MCL repair returned to play.

DISCUSSION

The major finding in this study is that there were no significant differences in PROs and activity level between the 3 common treatment strategies, including ACL reconstruction with (1) nonoperative MCL, (2) MCL repair, or (3) MCL reconstruction. The KOOS (symptoms, sports, quality of life, pain, activities of daily living), Lysholm, IKDC,

TABLE 1
Systematic Review Study Design Data[a]

Author, Year	Level of Evidence[b]; Type of Study; Modified Coleman Score	Groups	Patients	Outcome Measure	Results
Halinen et al, 2006[19c]	Level 1 RCT 19/24	1. ACLR + MCL repair 2. ACLR + MCL NSx	1. 23 2. 24	ROM, laxity, Telos, quadriceps peak torque, 1-leg hop, IKDC knee evaluation, Lysholm activity Level	No differences in outcomes
Halinen et al, 2009[18c]	Level 2 RCT 19/24	1. ACLR + MCL repair 2. ACLR + MCL NSx	1. 23 2. 24	Knee ROM, quadriceps peak torque, 1-leg hop	No difference in extension ROM; less flexion early in MCL repair, equal long term; early increased quadriceps deficit in MCL repair, equal long term
Ateschrang et al, 2016[5]	Level 2 Prospective nonrandomized trial 12/16	1. ACLR + MCL NSx	1. 16	Lysholm, Tegner, ROM, valgus stability	ROM and valgus knee stability improved significantly from 6 weeks to 1 year
Dong et al, 2015[14]	Level 2 Lesser-quality RCT 16/24	1. ACLR + MCL ALR 2. ACLR + MCL TLR	1. 32 2. 32	Radiographic stress position test, Slocum test, IKDC assessment	Increased incidence rotatory instability with ALR at follow-up (34.4% vs 9.4%); medial opening and subjective IKDC scores improved without b/w group differences; no difference in IKDC extension/flexion deficit scores; at follow-up, 87.5% of patients in the ALR group and 90.6% in the TLR group had return to normal/nearly normal level of sports participation
Alm et al, 2021[3]	Level 3 Retrospective cohort study 19/24	1. Revision ACLR + MCL repair 2. Revision ACLR + MCLR	1. 36 2. 17	Pivot-shift test, IKDC scores, Lysholm, Tegner, leg alignment, lateral knee radiographs	MCLR was associated with lower failure rates (5.9%) compared with repair (36.1%). MCLR had less medial knee instability Lysholm scores in MCLR were higher; IKDC, Tegner were the same between groups
Pandey et al, 2017[38]	Level 3 Retrospective comparative study 15/24	1. MCL-PMC repair + ACL Nsx 2. MCL-PMC repair + ACLR	1. 15 2. 20	Valgus medial opening, ROM, Lysholm and IKDC scores, KT-1000 measurement, subjective feeling of instability	Mean Lysholm and IKDC scores higher in group 1; 60% patients in group 1 complained of instability vs 0% in group 2; all knees stable on follow-up; no difference in mean flexion loss
Svantesson et al, 2019[49]	Level 3 Retrospective cohort 18/24	1. ACLR + MCL NSx 2. ACLR + MCL suture repair 3. ACLR + MCLR	1. 657 2. 52 3. 84	ACL revision, 2-year KOOS	Lower ACLR revision risk with isolated ACLR vs ACLR + MCL NSx; no difference in revision risk with isolated ACLR vs ACLR + surgically managed MCL groups; concomitant MCL injury groups with lower 2-year KOOS vs isolated ACLR

(continued)

TABLE 1
(continued)

Author, Year	Level of Evidence[b]; Type of Study; Modified Coleman Score	Groups	Patients	Outcome Measure	Results
Westermann et al, 2019[51]	Level 3 Retrospective cohort 19/24	1. ACLR + MCL repair/reconstruction 2. ACLR + MCL NSx	1. 16 2. 11	Surgical chronicity, secondary procedures, MCL tear location, KOOS, IKDC Subjective form, Marx Activity Rating Scale	No difference in outcomes before or after 30 days; MCL operative group KOOS and IKDC scores and worse outcomes at baseline and at 2 years; tibial-sided injuries had lower baseline clinical scores
Blanke et al, 2015[8]	Level 4 Case series 7/16	1. ACLR + MCL repair	1. 5	Valgus stability, anterior stability, ROM with IKDC and Lysholm scores	Improved valgus stability (grade A IKDC medial stability); all with normal ROM (IKDC grade A), all with negative Lachman and pivot shift (IKDC grade A for both); all patients returned to normal (grade A, 87%) or near-normal (grade B, 13%) level of sports participation
Blanke et al, 2017[7]	Level 4 Case series 10/16	1. ACLR + MCL repair	1. 67	Valgus stability, ROM, AMRI, IKDC and Lysholm scores	64 (96%) had IKDC grade A valgus stability and 62 (93%) had IKDC grade A ROM at final follow-up; none had AMRI on exam and follow-up, mean Lysholm score of 93.9
Canata et al, 2012[10]	Level 4 Case series 11/16	1. ACLR + MCL repair	1. 36	KOOS, IKDC, Lysholm, Tegner Activity Level scores, valgus test, external rotation test	Improvement in all outcomes, negative valgus stress (<3-mm medial joint opening) and <6° of external rotation in all patients; 75% patients returned to preinjury level of activity, 11% did not practice due to fear of reinjury, 14% did not practice due to lack of time, and none abandoned sports because of knee problems
Kitamura et al, 2013[27]	Level 4 Case series 9/16	1. ACLR + MCLR 2. ACLR + PCLR + MCLR	1. 16 2. 9	IKDC evaluation form, Lysholm score, AP laxity, valgus stability	In ACL + MCL reconstruction series: all patients graded B and above for valgus instability and overall IKDC score; mean Lysholm 95.3; all patients with <5° of flexion loss, improved AP stability
Koga et al, 2012[28]	Level 4 Case series 11/16	1. ACLR + MCL proximal advancement 2. ACLR + MCL proximal advancement + MCL augmentation	1. 10 2. 4	Clinical and stress valgus stability, AP stability, Lysholm knee scale and subjective evaluation	Manual valgus laxity at 0° and 30° and stress radiography improved; Lysholm scale improved; 13 patients with negative Lachman

(continued)

TABLE 1
(continued)

Author, Year	Level of Evidence[b]; Type of Study; Modified Coleman Score	Groups	Patients	Outcome Measure	Results
Millett et al, 2004[32]	Level 4 Retrospective case series 11/16	1. ACLR + MCL NSx	1. 18	Lysholm, Tegner, KT-1000 measurement	Mean side-to-side difference was 2.3 mm postoperatively; all had valgus stability and high Lysholm scores
Osti et al, 2010[37]	Level 4 Case series 12/16	1. ACLR + MCLR	1. 22	IKDC knee evaluation; anterior, AP, and valgus laxity; ROM; Outerbridge classification; Lysholm and IKDC subjective forms	91% returned to preinjury activity; 95% with negative or grade I Lachman; 1-mm difference in side-side AP laxity; 91% valgus laxity equivalent to grade A, improved outcomes
Sankar et al, 2006[46]	Level 4 Retrospective case series 18/24	1. ACLR + MCL NSx	1. 12	Lysholm, valgus stability, ROM	All patients had valgus knee stability at final follow-up and high Lysholm scores; all patients returned to preinjury level of play
Zaffagnini et al, 2011[54]	Level 4 Case series 19/24	1. ACLR + MCL NSx	1. 20	IKDC, Lysholm, Tegner, WOMAC, KT-2000 measurement, Telos valgus stress radiographs	High Lysholm and IKDC scores; residual valgus laxity persisted but did not affect AP stability; radiographs showed medial joint opening of 1.7mm; time to return to sport was 4.3 months
Lind et al., 2020[29]	Level 3, Retrospective Cohort 19/24	1. ACLR + MCLR	1. 280	KOOS, valgus IKDC grading, Tegner, KT-1000	69% obtained normal valgus stability at 1 year, average stressvalgus gap 1.7 mm, low Tegner scores (4.2), KOOS improved compared to pre-operatively

[a]ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; ALR, anatomic ligament repair; AMRI, anteromedial rotational instability; AP, anteroposterior; b/w, **XXX**; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; MCL, medial collateral ligament; MCLR, medial collateral ligament reconstruction; NSx, nonoperative management; PMC, posterior medial corner; RCT, randomized clinical trial; ROM, range of motion; TLR, triangular ligament reconstruction; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[b]Levels of evidence according to the *Oxford Based Center for Evidence-Based Medicine guidelines.*

[c]These 2 studies by Halinen et al[18,19] present data from the same patients in an RCT.

Only cohorts 2, 3, and 4 were included in the data analysis (isolated ACLR group was excluded). Per authors, between-group analyses were unable to be performed in this study.

and Tegner activity scores were similar between all treatment strategies.

Lysholm scale[30] and IKDC evaluation[24,25] were the most frequently reported functional/subjective outcomes in these studies. The Lysholm scale was used in 13 studies,[#] with mean scores ranging from 89.1 to 96. There were no significant differences observed in the 3 summarized treatment options. It remains unclear why the overall range of these scores is similar to long-term studies of patients treated with isolated ACL reconstruction, but it may suggest that the Lysholm scale lacks sensitivity in differentiating between these treatment options.[44,50] Although the Lysholm score has been validated as a responsive tool up until 2-year follow-up,[9] we suspect that these discordant values may be reflective of a ceiling effect of the tool due to advancement in surgical technique and perioperative protocols. The IKDC evaluation was used in 11 studies,[**] and the proportion of patients with IKDC evaluation scores categorized as normal or near normal ranged from 60% to 100%. Interestingly, Halinen et al[19] reported an IKDC score that was normal or near normal in 83.8% of patients with MCL tears managed nonoperatively, compared with 70% in patients who underwent MCL repair.

Postoperative ROM has also been a measure of treatment success, with arthrofibrosis and stiffness being common complications with older surgical techniques. Problems with

[#]References 3, 5, 7, 8, 10, 19, 27, 28, 32, 37, 38, 46, 54.

**References 3, 7, 8, 10, 14, 19, 27, 37, 38, 51, 54.

TABLE 2
Descriptive Statistics

Study	Mean Follow-Up Time, mo (minimum-maximum)	Time From Injury to Surgery, wk	Age, y, mean (SD)	Percentage Male	Total Sample Size, No.
Alm et al, 2021[3]	28.9 (24.0-69.0)	Chronic	31.30 (12.00)	62.26	53
Ateschrang et al, 2016[5]	12.0 (. - .)[c]	1.5	36.40 (11.60)	62.5	16
Blanke et al, 2017[7]	18.0 (. – 18.0)[c]	.	39.00 (11.56)	47.76	67
Canata et al, 2012[10]	36.0 (24.0-84.0)	37	37.00 (14.44)	72.22	36
Desai et al, 2020[13]	50.0 (24.0-105.0)	5	23.30 (7.30)	81.25	16
Dong et al, 2015[14]	34.0 (24.0-48.0)	1.3	36.00 (10.00)	57.81	64
Halinen et al, 2006[19]	27.0 (20.0-37.0)	1.5	39.00 (10.60)	42.55	47
Halinen et al, 2009[18a]					
Kitamura et al, 2013[27]	.[c] (24.0-144.0)	148	28.60 (12.60)	80	30
Lind et al, 2020[29]	12.0 (. - .)[c]		33.20 (12.08)	31.43	280
Osti et al, 2010[37]	36.0 (24.0-52.0)	11.4	29.00 (6.21)	54.55	22
Pandey et al, 2017[38]	47.0 (24.0-90.0)		35.90 (11.25)	95	20
Piatkowski et al, 2014[41]	21.0 (9.0-30.0)		37.00 (13.40)	74.07	27
Sankar et al, 2006[46]	63.6 (31.2-98.4)	4.7	15.60 (1.46)	50	12
Svantesson et al, 2019[49b]	24.0 (. -60.0)[c]	.	27.90 (11.40)	65	287
Zaffagnini et al, 2011[54]	39.0 (36.0-49.0)	36	38.00 (14.70)	90	20

[a]The 2 studies by Halinen et al[18,19] present data from the same patients in a randomized controlled trial.
[b]Only 287 of patients from Svantesson et al[49] had 2 years of follow-up data available and were, thus, included in the meta-analysis.
[c]Blanks indicate missing information regarding follow-up that was not provided in the study.

TABLE 3
Patient-Reported Outcome Score and Range of Motion Meta-analysis[a]

Score	No Surgery Mean (Min, Max)	Reconstruction Mean (Min, Max)	Repair Mean (Min, Max)	*P* Value
KOOS Symptoms	77.6 (9.8, 100)	70.3 (23.2, 100)	84.2 (43.6, 100)	.98
KOOS Sport/Rec	70.1 (0, 100)	60.0 (0, 100)	70.6 (5.1, 100)	.80
KOOS QOL	57.1 (0, 100)	53.7 (0.8, 100)	61.9 (9.5, 100)	.97
KOOS Pain	81.3 (20.9, 100)	79.1 (32.0, 100)	90.6 (59.9, 100)	.84
KOOS ADL	89.6 (29.2, 100)	86.3 (41.1, 100)	98.5 (84.3, 100)	.87
Lysholm	95.3 (76.7, 100)	94.4 (46.7, 100)	92.8 (65.4, 100)	.62
IKDC (% A Grade)	66.4 (44.0, 88.9)	65.43 (41.8, 89.1)	53.1 (34.7, 71.6)	.42
Tegner	5.8 (0.39, 10)	5.0 (0.49, 9.5)	6.1 (3.4, 8.8)	.90
Normal Extension[b] (%)	100 (98.3, 100)	93.8 (86.6, 100)	99.8 (98.4, 100)	.20
Normal Flexion[b] (%)	86.7 (68.1, 100)	72.5 (45.9, 99)	86.6 (68.1, 100)	.45

[a]ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee (score measured in percentage points); KOOS, Knee injury and Osteoarthritis Outcome Score; QOL, Quality of Life; Sport/Rec, Sport and Recreation. Values are presented as means.
[b]Flexion and extension deficits are reported as percentage of patients with normal flexion and extension range of motion.

TABLE 4
Return to Sport/Activity After Respective MCL Treatments[a]

Treatment	Time From Injury to Surgery, wk	Return to Sport	Authors
ACLR + nonsurgical MCL	37	100%	Sankar et al, 2006[46]
	36	4.3 mo[b]	Zaffagnini et al, 2011[54]
ACLR + MCL repair	6	91%	Osti et al, 2010[37]
	37	75%	Canata et al, 2012[10]

[a]ACLR, anterior cruciate ligament reconstruction; MCL, medial collateral ligament.
[b]Zaffagnini et al. reported only average time to return to sport, and did not explicitly report percent of patients that returned to sport.

ROM at the time of final follow-up were rarely reported in any of the above studies with the exception of Westermann et al,[51] who published a 19% reoperation rate for stiffness in surgically treated MCLs and Pandey et al,[38] who observed a mean 12° of flexion loss in nonoperatively managed ACL and MCL combined injuries. Therefore, both nonoperative and operative MCL management can lead to arthrofibrosis in the setting of ACL surgery. However, the Westermann et al[51] study from the Multicenter Orthopaedic Outcomes Network (MOON) group reported a 9% reoperation rate for nonoperatively treated MCL injuries, and reoperation rates between operative and nonoperative MCL treatments were not statistically different overall. Furthermore, ROM losses in the Pandey et al[38] study may be due in part to a prolonged 3-week immobilization period after surgery used in that study's protocol. We believe this overall decreased incidence of arthrofibrosis is largely the result of advancements in surgical technique and modern postoperative rehabilitation protocols stressing early ROM.[42,54]

Return-to-play rate was reported in only 4 studies, and only 1 study reported on time to return to play. The mean weighted return to play for each of the treatment options was 100% (nonoperative MCL + ACL reconstruction) and 75% (MCL repair + ACL reconstruction). This may indicate that MCL repair in the context of ACL injury may reduce the likelihood of return to play. However, time to return to play was poorly reported, and we were unable to quantitatively assess this factor in our meta-analysis. One study showed that patients who had ACL reconstruction with nonoperatively managed grade II MCL returned to play at a mean of 4.3 months, significantly faster than most ACL rehabilitation protocols suggest.[54] Future studies should closely evaluate level of return to play, as well as time to return to play.

Review of Literature

Some studies discussed findings outside of this meta-analysis that merit consideration. The overall benefits of nonoperative management of MCL injuries are currently unclear. In comparing MCL repair to nonoperative management, patients who underwent MCL repair had a slower rate of functional recovery when compared with those undergoing nonoperative management. When compared with those who had nonoperative management of MCL injuries, it took patients who underwent MCL repair 52 weeks to gain equivalent ROM and 104 weeks for equivalent quadriceps strength, indicating that patients with nonoperatively treated MCL injuries recovered ROM and quadriceps strength more quickly.[18] While the current analysis did not reveal differences between operative treatments and nonoperative management, more research is needed to clarify the role of MCL operation on the relationship between return-to-play rates and knee mechanical stability.

Given the possible success of nonoperative management of the MCL portion of a combined ACL-MCL injury, the question remains as to how long one should pursue this strategy before the decision for MCL repair or MCL reconstruction with ACL reconstruction. A study by Blanke et al[7] that introduced a novel subclassification of patients may provide some guidance. The novel subclassification was based on the presence of anteromedial rotatory instability (AMRI) identified at 6 weeks after injury evaluation. At this 6-week mark, residual grade I MCL injuries were treated nonoperatively, and all patients treated with remaining grade III MCL injuries were managed operatively. Grade II MCL injuries that had a negative Slocum test for AMRI were treated nonoperatively, whereas grade II MCL injuries with a positive Slocum test underwent MCL repair. At 18 months of follow-up, both the nonoperative and the operative groups demonstrated >90 Lysholm score, >90% full ROM, >90% anterior IKDC stability, and >87% valgus IKDC stability. In addition, no patients had residual AMRI, and all returned to a normal (87%) or near-normal (13%) level of sports.[7]

This delayed surgical decision-making is also supported within the MOON study group, which demonstrated no difference in KOOS and IKDC scores between patients with acute or delayed operative management.[51] Blanke et al[7] also defined AMRI as a positive Slocum test. The Slocum test is performed as a modification to the anterior drawer with 15° of external rotation of the tibia. A positive test demonstrates increased forward and outward displacement of the tibia relative to the femur and rotation of the medial tibial plateau compared with the contralateral side. In their study, patients with concomitant grade II proximal or distal MCL injury found to have AMRI underwent ACL reconstruction with MCL reattachment with blocking screw fixation, and they had excellent medial stability at follow-up. These results suggest that evaluation of rotatory instability must be considered in the treatment algorithm for combined ACL-MCL injury.[7] A review by Smyth and Koh[48] also advocated a tiered approach of delayed ACL reconstruction after a short period of bracing and early ROM, allowing low-grade MCL injuries to heal. In their approach, MCL stability is addressed with reconstruction when valgus instability or AMRI is encountered at the time of surgery.

Special consideration should be emphasized when the anterior superficial MCL fibers displace over the pes anserine tendons (Stener-type lesions), which is believed to impair healing to the tibia by preventing the MCL from contacting its original bony attachment site. We consider these lesions an indication for acute surgical management.[2] Strong consideration of acute management is also given to young, active patients, as well as competitive athletes, to minimize risks of cartilage and meniscal injury during the interim period of knee instability before surgery and to expedite return to sport.[11,16] In this setting, femoral or tibial avulsion injuries, including Stener-type lesions, would be repaired with suture anchors and consideration of augmentation with braided ultra–high molecular weight polyethylene and polyester for elite athletes (Arthrex). In comparison, midsubstance injuries for those who elect for acute treatment would be addressed with reconstruction.

Given the results of the meta-analysis and systematic review, a trial of nonoperative management appears appropriate except for special circumstances, including

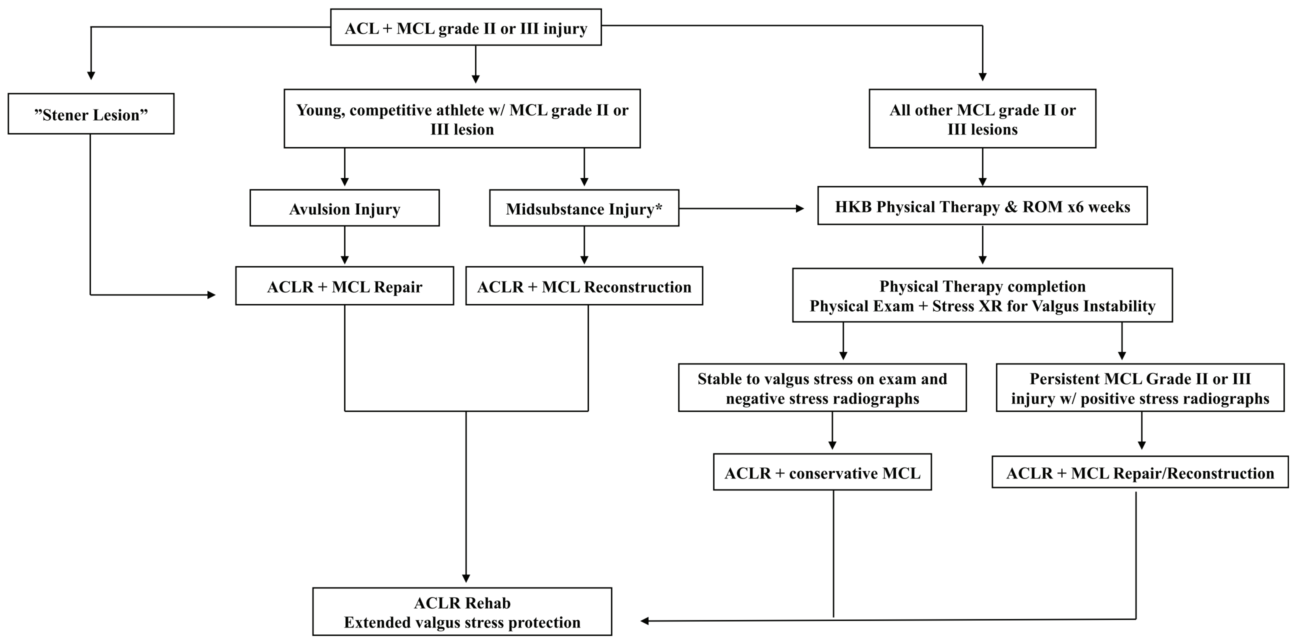

Figure 2. Algorithm for treatment of combined complete ACL and MCL injuries. Positive stress radiography (XR) represents isolated >6.5 mm or >3.2 mm compared with the contralateral side. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; HKB, hinged knee brace; MCL, medial collateral ligament; ROM, range of motion. *In young, competitive athletes with a midsubstance MCL tear, the decision between surgical vs nonsurgical treatment is made through thorough discussion with the patient and family.

Stener-type lesions, and in high-demand athletes with a grade 2 midsubstance MCL injury who desire expedited rehabilitation. A proposed algorithm based on these findings is outlined in Figure 2.

In addition to the findings above, we identified several novel surgical techniques for MCL repair and reconstruction. Several minimally invasive techniques were identified for MCL repair, including percutaneous bracing, proximal MCL-POL suture repaired to each other, and primary suture repair of midsubstance injuries.[5,10,37] All suture techniques were associated with improved PROs and at final follow-up had ≤1.1-mm side-to-side difference on stress radiographs between injured and noninjured knees.[5,10,37] Canata et al[10] advocated that MCL-POL proximal suture repair to each other at the level of the medial epicondyle be indicated for proximal injuries with a positive external rotation test. Two additional innovative repair approaches included an isolated MCL–posterior medial corner (PMC) repair without ACL reconstruction and an MCL tibial footprint elevation and repair with a blocking screw.[8,38] Pandey et al[38] reinforced the importance of the ACL reconstruction in combined ACL-MCL injuries, as patients with isolated MCL-PMC repair had significantly worse PROs and stability than patients who had both ACL and MCL-PMC injuries treated surgically.

A few case series have explored outcomes of novel operative reconstruction techniques of concomitant ACL-MCL injury.[27,28] Kitamura et al[27] reported on an anatomic reconstruction of the superficial MCL using a doubled autogenous semitendinosus graft secured with a hybrid fixation (femoral side via suspensory fixation and tibial side via cortical staples × 2) technique in patients with multiligamentous injuries. The ipsilateral semitendinosus tendon was harvested for the MCL reconstruction and the contralateral knee semitendinosus and gracilis tendons for the ACL reconstruction. Out of a series of 30 patients (mean age, 30 years; range, 16-60 years), 5 underwent combined MCL and ACL reconstruction and obtained grades of B and above for both valgus instability and overall IKDC score. Moreover, Lysholm scores (mean 95.3) and sagittal stability improved significantly, and all patients maintained <5° of flexion loss at 2-year follow-up.[27] Similarly, Koga and colleagues[28] published data on a case series of 18 patients with ACL and grade III MCL injuries (median age, 24 years; range, 17-44 years), 14 of whom underwent combined ACL-MCL reconstruction. MCL treatment involved the proximal MCL and POL sutured together and suture anchor repair, with 4 patients undergoing augmentation with doubled semitendinosus tendon sutured proximally over prior repair and stapled distally in the tibia. All patients demonstrated satisfactory valgus stability and improvement in Lysholm scores at 2-year follow-up.[28] In a series of patients with chronic ACL injuries combined with chronic grade II or III valgus instability, Zhang and colleagues[55] also published results of a tibial inlay MCL reconstruction technique with an Achilles bone-block allograft in patients (n = 21; mean age, 39.6 years; range, 19-57 years). All patients demonstrated valgus and sagittal stability and significant improvement in

IKDC scores at the mean 40-month follow-up while avoiding arthrofibrosis. Although promising, each of these novel techniques requires further prospective investigation to determine the optimal surgical technique.

Limitations

This study has several limitations. There was notable heterogeneity in the evaluation and classification of MCL injuries described in the included studies with the Hughston Modification of the American Medical Association classification,[22] the Fetto and Marshall[15] classification, and IKDC instability grade, which may introduce heterogeneity into the aggregated study population. We were unable to stratify MCL injuries by grade of tear, as most studies did not report these data. As such, it is likely that more severe, higher-grade injuries were more likely to be treated surgically. There also remains a paucity of high-level studies on this subject. Our search yielded only a single level 1 randomized controlled trial (RCT), 1 level 2 lesser-quality RCT, and 1 level 2 prospective nonrandomized trial that compared treatment groups. In addition, there was inconsistent reporting of concomitant injuries such as meniscal tears or chondral lesions, and we therefore did not evaluate nonligamentous injuries, which could affect outcomes.[34] The mean follow-up was just under 2 years, which is relatively short. In addition, 4 of the included articles in our study had <2-year follow-up, limiting conclusions that can be made about longer-term clinical outcomes. In addition, we acknowledge that wide ranges in patient follow-up and sample size between studies should be carefully considered when analyzing data regarding weighted means within this study. Variability in outcome reporting—namely, ROM and joint stability—prevented aggregation of data from these studies to strengthen the quality of this review. ROM in particular was reported inconsistently and heterogeneously, with some studies reporting percentage of patients with "normal" ROM and some reporting actual deficits in degrees.

CONCLUSION

There currently is a paucity of high-level studies regarding a treatment algorithm for combined grade II or III ACL-MCL injuries. The ACL is primarily reconstructed to restore anteroposterior plane stability, which has demonstrated favorable outcomes in the setting of nonoperatively managed MCL patients with low-grade tears. However, there remains a segment of patients who would benefit from MCL repair or reconstruction for persistent valgus or rotatory instability after a trial of hinged-knee brace stabilization and ROM. Delayed surgical management of 4 to 6 weeks has been shown to have equivalent outcomes to acute management. Future comparative studies focused on assessing current surgical options as well as identifying risk factors for treatment failure at long-term follow-up may further refine indications for surgical management of concomitant MCL injuries.

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