SYSTEMATIC REVIEW

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A High Percentage of Patients With Anterior Cruciate Ligament Tears Treated Nonoperatively Show Persistent Laxity on Arthrometer Assessment Despite Magnetic Resonance Imaging Evidence of Fiber Continuity: A Systematic Review

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Purpose: To evaluate magnetic resonance imaging (MRI) findings after nonoperatively treated anterior cruciate ligament (ACL) injuries and to assess objective knee stability using KT-1000/2000 arthrometer readings.
Methods: A systematic review was conducted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. A comprehensive search of Cochrane, Embase, Scopus, and Medline identified studies assessing ACL healing in nonoperative patients using MRI, arthrometer (KT-1000/2000), or arthroscopic evaluation. Inclusion criteria were: (1) studies that evaluated patients with ACL tears treated nonoperatively, (2) studies that used MRI to assess ACL healing, and (3) human studies published in English. Exclusion criteria were: (1) studies that did not use objective measures to assess ACL healing in nonoperative patients, (2) cadaveric studies, and (3) case reports and conference abstracts. Data extraction included demographics, treatment approaches, imaging findings, arthrometer and arthroscopic results, and patient-reported outcome measures.
Results: Seven studies with 351 patients (mean age: 30.1 years) met inclusion criteria. The studies had a mean follow-up time of 11.3 months (range: 6-30 months). MRI showed ACL fiber continuity in 85.6% (95% confidence interval: 84.5-86.6; standard deviation: 9.7; range: 70-100) of patients at follow-up. However, this did not correlate with clinical findings as arthrometer (KT-1000/2000) readings only revealed ACL stability in 54.7% (95% confidence interval: 53.4-55.9; standard deviation: 24.1; range: 2-85.7) of cases. Patient-reported outcomes showed a relatively good return of knee function, but 21.9% (standard deviation: 3.2; range: 14.3-25.8) of patients eventually underwent delayed anterior cruciate ligament repair. Additionally, 7.1% (standard deviation: 2.9; range: 5.9-14.3) of nonoperative patients experienced a reinjury.
Conclusions: Although MRI may show continuity of ACL fibers with nonoperative treatment protocols, KT-1000/2000 findings suggest that joint laxity persists.
Level of Evidence: Level IV, systematic review of Level II to IV studies.

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Anterior cruciate ligament (ACL) injury is one of the most common orthopaedic injuries and subsequent reconstruction of the ACL is a cost-effective treatment with favorable outcomes.[1-4] Despite this, nonoperative treatment of ACL tears has gained increased attention, with some studies showing that early ACL reconstruction does not result in better patient-reported outcome measures (PROMs) than nonoperative management.[5,6] In addition, nonoperative management allows patients to avoid potential surgical complications and have shorter rehab times.[7-9] However, the success of nonoperative management should be evaluated with objective measures.

One measure to evaluate ACL healing is assessing the continuity of fibers on magnetic resonance imaging (MRI), which has been utilized in nonoperative treatment studies.[10] Additional measures include the use of the KT-1000/2000 arthrometer or diagnostic arthroscopy. However, there is a lack of consensus regarding the MRI's utility in assessing true biological and functional healing of the ACL.[11,12] While restoration of fiber continuity and a homogenous signal on MRI indicate healing, it is unclear if these image findings correlate with stability or favorable outcomes. Due to the consequences of persistent ACL deficiency, it is important for healing progression to be accurately evaluated, as continued ACL injury and increased time to ACLR may be associated with meniscal and cartilage pathology.[13,14]

The purpose of this systematic review was to evaluate MRI findings after nonoperatively treated ACL injuries and to assess objective knee stability using KT-1000/2000 arthrometer readings. We hypothesized that although MRI findings may show continuity of the ACL fibers, arthrometer findings would show persistent laxity of the knee, suggesting that MRI findings alone are not an accurate assessment of functional healing.

METHODS

This review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for reporting systematic reviews.

Search Strategy

A search strategy was implemented to query Cochrane, Embase, Scopus, and Medline databases with no restriction on publication date. The initial literature search was conducted in October 2024. This search strategy aimed to identify all studies that investigated the use of MRI, and arthrometer or arthroscopic findings to assess ACL healing in patients treated nonoperatively. Search terms included "ACL Tear," "Nonoperative Management," "Arthrometer," and "MRI Findings" to identify relevant articles.

Inclusion criteria were: (1) studies that evaluated patients with ACL tears treated nonoperatively, (2) studies that used MRI to assess ACL healing, and (3) human studies published in English. Exclusion criteria were: (1) studies that did not use objective measures (KT-1000/2000 or arthroscopic evaluation) to assess ACL healing in nonoperative patients, (2) cadaveric studies, and (3) case reports and conference abstracts.

Assessment of Eligibility and Study Selection

The initial search yielded 531 articles. After removing 60 duplicate studies, 471 studies remained. Two independent reviewers applied the aforementioned exclusion criteria to the titles and abstracts of the studies, resulting in 429 studies being removed. A full-text review of the remaining 42 articles was conducted based on the established criteria. Any disagreements encountered during this process were resolved by an independent third reviewer. Only studies that included MRI findings of ACL healing in nonoperative patients were included. Following the search process, 7 articles were identified that met the criteria. A Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart detailing the search strategy is included in Figure 1.

Assessment of Study Quality

Study quality was assessed using the Methodological Index for Non-randomized Studies (MINORS).[15] This checklist consists of 8 items for noncomparative studies and 4 additional items for comparative studies. Noncomparative studies are scored out of 16 points, while comparative studies are scored out of 24 points. For noncomparative studies, the scores are as follows: 0 to 4 indicates very low quality, 5 to 8 indicates low quality, 9 to 12 indicates moderate quality, and 13 to 16 indicates high quality. For comparative studies, the scores are as follows: 0 to 6 indicates very low quality, 7 to 12 indicates low quality, 13 to 18 indicates moderate quality, and 19 to 24 indicates high quality.

Data Extraction

Extracted data included: (1) study characteristics: title, author, publication year, study design; (2) patient baseline

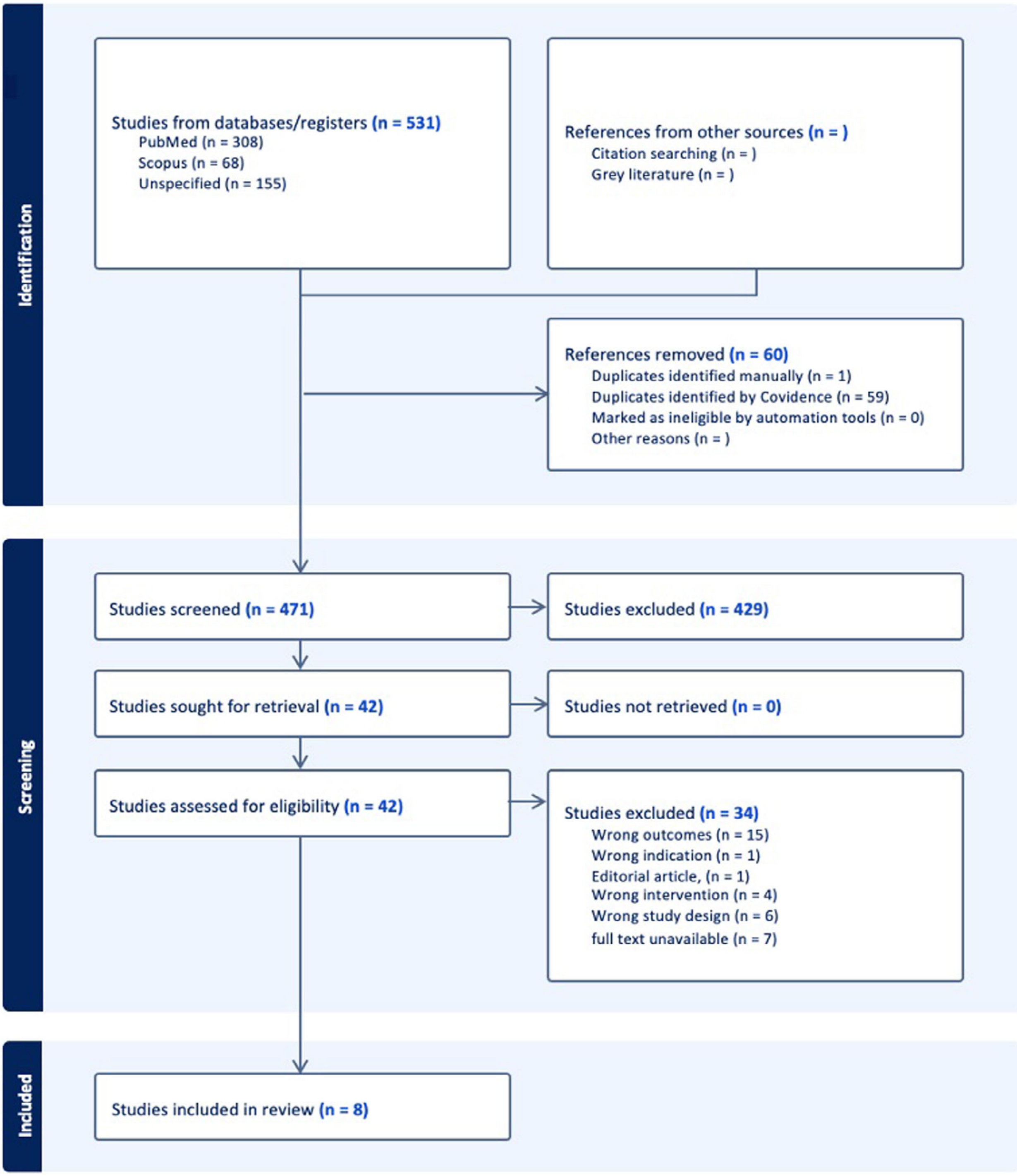

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart of search strategy results.

demographics: number of participants, sex, body mass index, age; (3) approach to nonoperative treatment; (4) whether MRI findings were used to assess ACL healing; (5) additional objective findings of ACL healing such as arthrometer or arthroscopic findings, and (6) patient outcomes: number of patients who underwent delayed ACLR, retear rate, and PROMs.

Statistical Analysis

Following data extraction, formal comparative statistics were performed by a departmental statistician using SAS/STAT software (SAS Institute Inc, Cary, North Carolina). Statistics such as weighted means, standard deviations, and confidence intervals were calculated. Additionally, evaluation of heterogeneity was performed by calculating Q statistic and I^2 values and creating forest plots.

RESULTS

Study Characteristics and Demographic Data

A total of 351 patients with acute ACL injuries treated nonoperatively were evaluated across the 7 included studies. There were 242 male and 189 female patients. The weighted mean age was 30.1 years (standard deviation: 1.9; range: 27.9-33) and the weighted mean follow-up time was 11.3 months (standard deviation: 6.9; range: 6-30). Further demographic data can be referenced in Table 1.

Risk of Bias

There were 6 noncomparative studies and 1 comparative study included in this review. None of the studies received full scores according to the MINORS criteria.[15] The mean MINORS score for all noncomparative studies was 9.5, indicating overall moderate study quality. Further information on individual study scoring according to the MINORS criteria can be referenced in Table 2.

Assessment of Heterogeneity

Substantial heterogeneity was observed when evaluating the differences between mean age and mean follow-up duration between the included studies. The weighted mean age was 30.1 years, with a Q statistic of 1221.9 and an I^2 value of 99.5%. This indicates significant interstudy variability with respect to the age of patients in the study cohort (Figure 2). Additionally, the weighted mean follow-up duration between studies was 11.3 months, with a Q statistic of 16833.6 and an I^2 value of 99.96%. This also indicates significant interstudy variability with respect to the follow-up durations between studies (Figure 3).

Treatment Approaches and Healing Assessment Protocols

In the study by Jacobi et al.,[21] patients were randomized into an ACL reconstruction group or a nonoperative functional bracing group. All other included studies placed patients exclusively into nonoperative treatment with no rationale provided for the reasoning of this treatment option. Table 3 describes the grade of ACL tear, the treatment protocols, and the methods used to assess ACL healing. ACL tears are commonly graded using the following classification: Grade 1—ACL mildly stretched, Grade 2—ACL stretched and partially torn, and Grade 3—complete ACL tear.[22]

Brace Protocols

A variety of brace protocols were used for nonoperative management, with all knees being immobilized soon after ACL injury and braces being in place for an average of 3 months (range: 2-4 months).[16,18,21] Specific protocols

TABLE 1 Study Characteristics and Demographic Data

Author	Journal	Year Published	Level of Evidence	Study Design	Number of Patients: Total	Male	Female	Mean Age, yr	Mean MRI Follow-Up, mo
Ihara and Kawano[17]	*Journal of Computer Assisted Tomography*	2017	IV	Case series	102	44	58	28.3	9.2
Jacobi et al.[21]	*Advances in Orthopaedics*	2016	III	Prospective cohort	84	52	32	32	6
Van Meer et al.[20]	*Arthroscopy*	2014	II	Prospective comparative study	50	33	17	29.9	24
Costa-Paz et al.[19]	*Clinical Orthopaedics and Related Research*	2012	IV	Case series	14	12	2	31	30
Chung et al.[12]	*Korean Journal of Radiology*	2007	IV	Case series	20	13	7	32	7.5
Fujimoto et al.[16]	*Archives of Orthopaedics and Trauma Surgery*	2002	III	Prospective cohort	31	10	21	33	12
Ihara et al.[18]	*Journal of Computer Assisted Tomography*	1996	IV	Case series	50	29	21	27.9	7.4

MRI, magnetic resonance imaging.

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TABLE 2 MINORS Score for Risk of Bias Assessment

	Chung et al.[12]	Fujimoto et al.[16]	Ihara and Kawano[17]	Ihara et al.[18]	Costa-paz et al.[19]	Van Meer et al.[20]	Jacobi et al.[21]
1. A clearly stated aim	2	2	2	2	2	2	2
2. Inclusion of consecutive patients	2	2	2	2	1	2	2
3. Prospective collection of data	2	2	2	2	0	2	1
4. Endpoints appropriate to the aim of the study	2	2	2	1	2	2	2
5. Unbiased assessment of the study endpoint	0	0	0	0	0	0	0
6. Follow-up period appropriate to the aim of the study	1	1	1	1	2	2	2
7. Loss to follow-up less than 5%	0	2	2	0	2	2	0
8. Prospective calculation of the study size	0	0	0	0	0	0	0
Items 9 to 12 only for comparative studies							
9. An adequate control group	-	-	-	-	-	2	-
10. Contemporary groups	-	-	-	-	-	2	-
11. Baseline equivalence of groups	-	-	-	-	-	1	-
12. Adequate statistical analyses	-	-	-	-	-	1	-
MINORS score	9	11	11	8	9	18	9
Maximum possible score	16	16	16	16	16	24	16

MINORS, Methodological Index for Non-randomized Studies.[15]

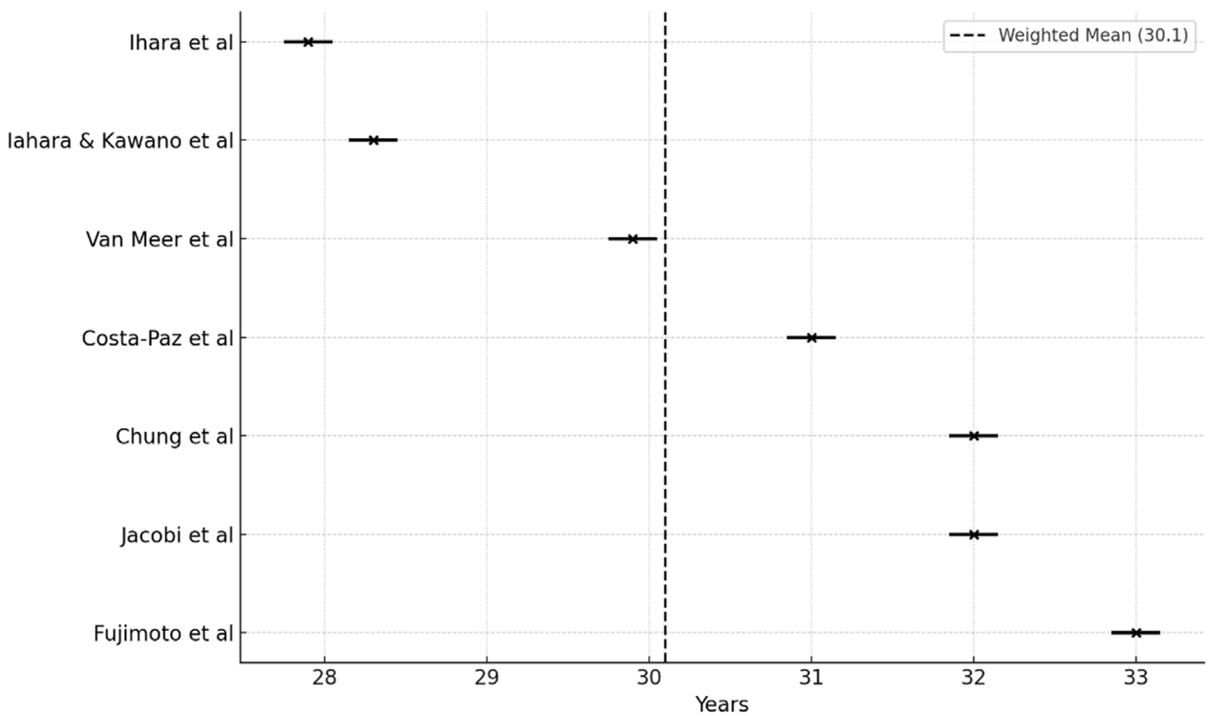

FIGURE 2 Forest plot of study cohort ages.

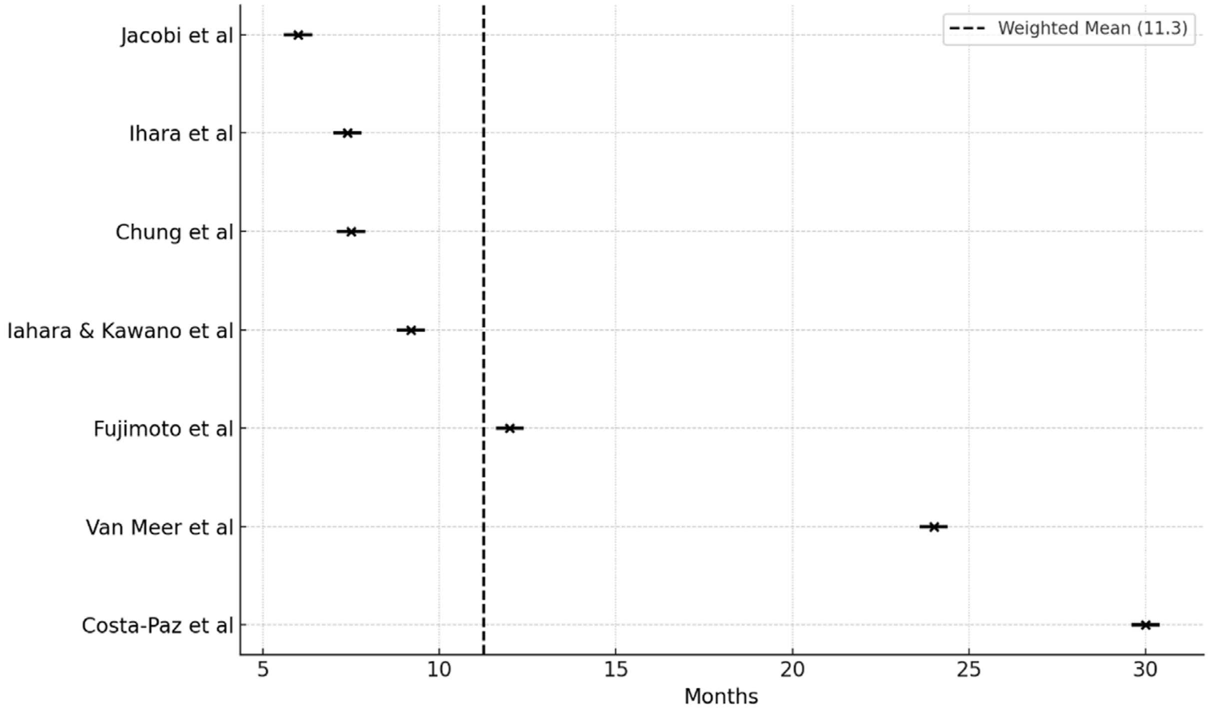

FIGURE 3 Forest plot of study cohort follow-up durations.

TABLE 3 Treatment Approaches and Healing Assessment Protocols

Authors	ACL Tear Grade	Physical Therapy?	Bracing Protocol	MRI Assessment of Healing	KT-1000/ 2000 Use	Arthroscopic Findings?
Chung et al.[12]	Grade 3	No	Yes, unspecified	Yes	Yes	Arthroscopic evaluation in 8/20 patients
Fujimoto et al.[16]	Grade 3	Yes	Nakamura Brace	Yes	Yes	-
Ihara and Kawano[17]	Grade 1-3	Yes	Kyuro Brace	Yes	Yes	-
Ihara et al.[18]	Grade 3	No	Kyuro Brace	Yes	No	Arthroscopy for all patients in study
Costa-Paz et al.[19]	Grade 3	No	No	Yes	Yes	-
Jacobi et al.[21]	Grade 2-3	Yes	ACL-Jack Brace	Yes	Yes	-
Van Meer et al.[20]	Grade 1-3	Yes	Yes, unspecified	Yes	Yes	-

ACL, anterior cruciate ligament; MRI, magnetic resonance imaging.

followed in the included studies can be found in Table 2. Fujimoto et al.[16] utilized a soft-single-hinged brace (Nakamura Brace) for 3 months with a 20° extension block. Ihara and Kawano[17] and Ihara et al.[18] utilized the Kyuro Knee brace for 3 months. This brace minimizes abnormal sagittal deviation between the femur and tibia by maintaining knee flexion. Lastly, Jacobi et al.[21] utilized an ACL-jack brace to prevent anterior tibial translation.

Physical Examination Findings

Studies that assessed ACL integrity via Lachman test had a weighted average normal result of 50.5% (standard deviation: 22.1; range: 32-93) at follow-up. Among studies that assessed pivot shift test performance, a weighted average of 62.1% (standard deviation: 32.3; range: 8-100) of patients had normal findings at follow-up.[16,18,20] Results

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TABLE 4 Physical Examination Findings and Patient-Reported Outcomes

Authors	Lachman	Pivot Shift	Clinical Scores (IKDC, TAS, Lysholm)
Chung et al.[12]	-	-	-
Fujimoto et al.[16]	14/23 (61%) regained endpoint same as contralateral knee	16/23 (70%) normal	-
Ihara and Kawano[17]	-	83/102 (81%) normal	-
Ihara et al.[18]	-	-	-
Costa-Paz et al.[19]	13/14 (93%) normal	14/14 (100%) normal	**TAS:** 7/10[†]
			Lysholm: 96.9/100 (range: 90-100)*
Jacobi et al.[21]	-	-	**Baseline: TAS:** 6.6/10 ± 2 (4-10)
			Lysholm: 99.7/100 ± 1.2 (95-100)
			IKDC: 96.5/100 ± 5.2 (72-100)
			Follow-up: TAS: 5.9/10 ± 2.0 (3-10)
			Lysholm: 93.3/100 ± 8.3 (67-100)
			IKDC: 90/100 ± 8.7 (69-100)
Van Meer et al.[20]	16/50 (32%) normal	4/50 (8%) normal	-

IKDC, International Knee Documentation Committee Subjective Knee Form; TAS, Tegner Activity Scale.
*Baseline scores not reported.
†Baseline scores not reported. Article states that TAS remained the same in 7 patients and declined in 7 patients at follow-up.

of follow-up physical exam tests are further detailed in Table 4.

PROMs

PROMs were also used to assess postoperative function.[16,17,19-21] None of the included studies reported minimal clinically important difference, patient acceptable symptom state, or substantial clinical benefit. Outcomes were reported as mean scores or as group-level assessments. Averages of the scores were reported but no percentage of subjects who met or exceeded the threshold values. The average Lysholm score for 98 patients at follow-up across studies was 93.8 (range: 93.3-96.9), indicating an “excellent” level of knee function. The average Tegner Activity Scale score across studies was 6.5 (range: 5.9-7), indicating that patients were able to return to recreational activity. Lastly, the International Knee Documentation Committee score was only reported in 1 study with an average score of 90 across patients at follow-up (range: 69-100), indicating that patients regained a relatively high level of knee function.[21] Further details of these PROMs can be referenced in Table 4.

Assessment of ACL Healing

MRI was used to assess the progression of ACL healing in all studies [weighted mean follow-up: 11.3 months (standard deviation: 6.9; range: 6-30 months)]. Across all studies, a weighted mean of 85.6% (95% confidence interval: 84.5-86.6; standard deviation: 9.7; range: 70-100) of patients showed ACL continuity of fibers on imaging at follow-up.

ACL healing was also assessed using the KT-1000/2000 arthrometer in 5 studies.[12,16,19-21] A weighted mean of 54.7% (95% confidence interval: 53.4-55.9; standard deviation: 24.1; range: 2-85.7) of patients showed normal arthrometer findings on follow-up. The included studies defined this as less than a 3 to 5 mm side-to-side difference or less than a 4 mm change from baseline.

Two studies also used diagnostic arthroscopy to assess ACL healing.[12,18] The weighted mean rate of ACL healing determined by arthroscopy was 75% (standard deviation: 16.3; range: 37.5-90). Chung et al.[12] further discussed arthroscopic findings in the study cohort: 8 patients with a previously diagnosed ACL injury treated nonoperatively received diagnostic arthroscopy to determine the level of ACL healing. Five of these ACLs were found to be torn and showed higher signal intensity/heterogeneity on MRI. The remaining 3 were deemed intact and had increased variability in their signal intensity. Further information detailing MRI, arthrometer, and arthroscopic findings can be referenced in Table 4.

MRI Grading Scales

While ACL continuity of fibers on MRI at various follow-up visits was reported across studies, differing MRI grading scales were used. Three studies utilized the ACL OsteoArthritis Score system to assign a grade of 0 to 3 to each patient to quantify healing.[16,19] Grade 0 indicated a normal ligament with a hypointense signal and regular thickness and continuity, grade 1 indicated a thickened ligament with a high intraligamentous signal, grade 2 indicated a thin and elongated ligament, while grade 3 indicated complete ACL discontinuity.

Ihara and Kawano utilized a morphologic grading system for healing: grade 1 ligaments were continuous, grade 2 ligaments were straight and continuous with partial thinning, grade 3 ligaments had a greater degree of thinning, and grade 4 ligaments were discontinuous. At the final follow-up, there were 41 patients with grade 1, 17 with grade 2, 25 with a grade 3, and 19 with grade 4.[17]

The remaining studies did not define a grading system for ACL healing. Ihara et al.[18] reported that 74% of ligaments had full continuity at follow-up. Jakobi et al.[21] reported 36 patients with full ACL continuity and 25 patients with irregular or thin ligaments that were continuous. The study by Van Meer et al.[20] reported that at a 2-year follow-up, 12 patients showed fully continuous ligaments and 23 showed only partial continuity.

Delayed Surgical Repair and Retear Rate

Four studies reported the rate of delayed ACLR.[12,16,19,21] The rate of patients crossing over to delayed ACLR was as high as 25.8% with a weighted mean of 21.9% (standard deviation: 3.2; range: 14.3-25.8). Two studies also reported subsequent ACL reinjury in patients who had showed ligament continuity and a homogeneous signal on MRI, findings indicative of nonoperative ACL healing, with rates as high as 14.3%.[12,19] The weighted mean ACL retear rate was 7.1% (standard deviation: 2.9; range: 5.9-14.3). Further details on ACL healing outcomes, rates of delayed ACLR between studies, and retear rates are found in Table 5.

DISCUSSION

The most important finding in this study is that despite MRI displaying continuity of ACL fibers after nonoperative treatment, KT-1000/2000 measurements revealed that a large percentage of knees showed continued laxity (45.3%), defined as more than 3 to 5 mm side-to-side difference or greater than 4 mm change from baseline.

MRI is the primary imaging tool used in clinical practice to help confirm ACL tear diagnosis. Prior studies have shown that MRI reliably diagnoses ACL tears with a consistency close to that of arthroscopy.[23] While this shows that MRI findings are useful in assessing acute ligamentous injury, its utility in assessing healing after injury is unclear. Our study showed a discrepancy between ACL continuity of fibers on MRI (85.6%) and normal laxity on arthrometer readings (54.7%). Of the 6 studies that evaluated both MRI and arthrometer/arthroscopic findings, 5 reported a higher rate of ACL fiber continuity on MRI than arthrometer and arthroscopic findings.[12,16,19-21] This illustrates the increased risk of false negatives if ACL healing is assessed by MRI alone. Previous literature suggests that

TABLE 5 ACL Healing Outcomes

Authors	Patient's Achieving ACL Fiber Continuity on MRI (%)*	ACL Healing Based on Arthrometer Findings at Follow-Up (KT1000/2000) (%)	ACL Healing Based on Arthroscopic Findings at Follow-Up (%)	Delayed ACLR (%)	Retear Rate (%)
Chung et al.[12]	20/20 (100%)	11/20 (55%)	3/8 (37.5%)	5/20 (25%)	-
Fujimoto et al.[16]	31/31 (100%)	20/31 (64.5%)	-	8/31 (25.8%)	-
Ihara and Kawano[17]	83/102 (81.4%)	-	-	-	-
Ihara et al.[18]	41/50 (82%)	-	45/50 (90%)	-	-
Costa-Paz et al.[19]	14/14 (100%)	12/14 (85.7%)	-	2/14 (14.3%)	2/14 (14.3%)
Jacobi et al.[21]	61/66† (92.4%)	55/66† (83.3%)	-	18/84‡ (21%)	5/84‡ (5.9%)
Van Meer et al.[20]	35/50 (70%)	1/50 (2%)	-	-	-

ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament repair; MRI, magnetic resonance imaging.
*Complete ACL continuity on MRI at follow-up (avg 8.2 months [standard deviation: 10.1; range: 6-30]).
†Proportion of patients determined as being "successfully treated" with brace.
‡Proportion of total study population treated with bracing protocol.

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MRI findings alone are unreliable for evaluating complete versus incomplete ACL tears and that this metric may be prone to false negatives.[10] Despite MRI findings suggesting structural integrity, 21.9% of patients still went on to delayed ACLR, suggesting that they experienced symptoms of continued ACL insufficiency.

KT-1000/2000 provides a quantifiable measure of laxity. A previous study revealed that KT-1000 had the highest diagnostic value among all noninvasive clinical tests when assessing ACL injuries.[24] Other studies have evaluated the intra- and inter-rater reliability of KT-1000 measurements. Findings show acceptable intra-rater reliability between measurements, while inter-rater reliability was shown to be less accurate.[24] This may explain the wide range of reported arthrometric findings across studies.

Another discrepancy to note is with PROMs at follow-up. Across all studies in this review, Tegner Activity Scale, Lysholm, and International Knee Documentation Committee scores revealed that patients regained relatively high function in their injured knees. However, this contradicts KT-1000 findings as these indicated the presence of persistent joint laxity at follow-up. This finding is in line with multiple studies that have shown no clinically relevant association between KT-1000 measurements and PROMs at follow-up as long as 16 years after treatment.[25-29] This further emphasizes the clinical importance of evaluating objective, quantifiable metrics to determine healing.

Arthroscopic evaluation also provides further insight into ACL healing. Chung et al.[12] revealed that 100% of patients in the study showed continuity of fibers on MRI, while only 37.5% of patients who underwent diagnostic arthroscopy showed signs of healing progression. While arthroscopic findings further emphasize the apparent discrepancy with MRI findings, arthroscopy may not be a viable option for patients to diagnose ACL healing due to its invasive nature.[23]

One possible explanation for the high rate of fiber continuity on MRI in patients treated nonoperatively may be due to scarring of the ACL into the posterior cruciate ligament (PCL). This would give the appearance of continuity when ligamentous insufficiency is still present.[23,30] Another possibility is due to an isolated tear of the anteromedial (AM) or posterolateral (PL) bundle. MRI prediction has shown to be particularly inaccurate when diagnosing a PL bundle tear at various time points after injury, therefore decreasing its reliability in such cases.[31] Physical examination tests such as the pivot shift test can also be used to evaluate rotational instability, which is often associated with partial ACL tears. Van Meer et al.[20] showed that 70% of patients had continuity of fibers on imaging, however, only 8% of patients had a normal pivot shift test. This finding may be attributed to a persistent tear of the PL bundle.

Results of the KANON trial revealed no difference in PROMs at 2-year follow-up between early ACLR and nonoperative treatment with optional delayed ACLR.[6] However, it should be noted that patients in the delayed ACLR cohort showed a high rate of crossover (39%) and instability compared with the early ACLR group (32% vs 3%).[6] Similarly, in our study cohort, 21.9% of patients went on to delayed ACLR, while 7.1% experienced a reinjury. Delayed ACLR is more likely to lead to meniscus and cartilage pathology as shown in multiple studies.[13,14] A major limitation of the KANON trial was the absence of blinding. Selection bias may have been present as patients who opted to undergo nonoperative treatment may have been more satisfied with that protocol. This may have led to better patient-reported outcomes in the nonoperative treatment group.

In the included studies, patients were not randomized to either treatment protocol. Therefore, selection bias may have led to better PROMs among those treated nonoperatively. While patients reported good clinical outcomes in our study cohort, such outcomes did not correlate with objective arthrometer and arthroscopic findings. Filbay et al. provided a flow chart depicting the patient selection process: 5 patients were not offered conservative treatment due to concomitant injuries, 17 patients elected to undergo ACLR due to physical demand and external pressures, and another 15 patients chose ACLR after being informed of a greater chance of suboptimal healing. Another study only selected patients with low athletic demand and sedentary occupations.[16] Thus, PROMs after nonoperative treatment may not be applicable to a more active population.

Limitations

Significant heterogeneity was observed between the included studies, specifically when evaluating the age and follow-up durations between studies. While the included studies provided demographic information such as the proportion of male and female participants, they did not stratify or analyze outcomes by sex to assess the potential influence on outcomes. Therefore, we were not able to report sex specific findings in our article.

Furthermore, follow-up intervals were as low as 3 months and as high as 30 months after treatment. Shorter follow-up times may underestimate knee functional deficits. In addition, we could not find a definitive follow-up period to validate healing on MRI, as grafts continue to show changes beyond even the 30-month follow-up seen in Costa-Paz et al.[19] Since the included studies graded healing as a return of a homogenous signal of MRI, this article examined the time point at which the homogenous signal returned as a valid follow-up. As the purpose of our review was to show the discrepancy between MRI findings and laxity shown on KT-1000 or arthroscopy findings, the valid follow-up for MRI to assess healing was outside the scope of this article.

In addition, the included studies used differing bracing protocols. Therefore, the heterogeneity between nonoperative treatments makes it difficult to group these studies together. However, since the included studies have a low risk of bias and are of moderate quality, this makes pooling of the data suitable so long as the findings of this study are interpreted in this context and are used to guide further research. Furthermore, since treatment protocols were nonrandomized in the included studies and only patients treated nonoperatively were evaluated, it is possible that the study population may have been less symptomatic and more active at baseline—this may have influenced our study's findings. In addition, the review only included studies with small numbers of patients and revealed low levels of evidence. Lastly, differing measures of healing were assessed. Some studies assessed laxity using KT-1000/2000 at follow-up while some had patients undergo diagnostic arthroscopy.

CONCLUSIONS

Although MRI may show continuity of ACL fibers with nonoperative treatment protocols, KT-1000/2000 findings suggest that joint laxity persists.

DISCLOSURES

The authors (A.C., E.B., A.M.) declare the following financial interests/personal relationships which may be considered as potential competing interests: A.C. reports a relationship with Arthrex Inc that includes: consulting or advisory: and reports a relationship with American Orthopaedic Society for Sports Medicine that includes board or committee membership. E.B. reports a relationship with EBSCO that includes: board membership; reports a relationship with Link Orthopaedics Pty that includes: consulting or advisory; reports a relationship with Orthopaedic Design NA that includes: consulting or advisory. A.M. reports a relationship with ConMed that includes other professional activities and reports a relationship with *Arthroscopy* that includes editorial or governing board. The other authors (D.D., C.R., C.B., M.H., I.L., R.B., T.E., W.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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