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# Physical Examination Tests for the Diagnosis of Posterior Cruciate Ligament Rupture: A Systematic Review



**STUDY DESIGN:** Systematic literature review.

**OBJECTIVES:** To summarize and evaluate research on the accuracy of physical examination tests for diagnosis of posterior cruciate ligament (PCL) tear.

**BACKGROUND:** Rupture of the PCL is a severe knee injury that can lead to delayed rehabilitation, instability, or chronic knee pathologies. To our knowledge, there is currently no systematic review of studies on the diagnostic accuracy of clinical examination tests to evaluate the integrity of the PCL.

**METHODS:** A comprehensive systematic literature search was conducted in MEDLINE from 1946, Embase from 1974, and the Allied and Complementary Medicine Database from 1985 until April 30, 2012. Studies were considered eligible if they compared the results of physical examination tests performed in the context of a PCL physical examination to those of a reference standard (arthroscopy, arthrotomy, magnetic resonance imaging). Methodological quality assessment was performed by 2 independent reviewers using the revised version of the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.

**RESULTS:** The search strategy revealed 1307 articles, of which 11 met the inclusion criteria for this review. In these studies, 11 different physical examination tests were identified. Due to differences in study types, different patient populations, and methodological quality, meta-analysis was not indicated. Presently, most physical examination tests have not been evaluated sufficiently enough to be confident in their ability to either confirm or rule out a PCL tear.

**CONCLUSION:** The diagnostic accuracy of physical examination tests to assess the integrity of the PCL is largely unknown. There is a strong need for further research in this area.

**LEVEL OF EVIDENCE:** Diagnosis, level 3a.
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**KEY WORDS:** *posterior cruciate ligament, posterior drawer, posterior sag sign, quadriceps active, sensitivity, specificity, systematic review*

Rupture of the posterior cruciate ligament (PCL) is a severe knee injury that can lead to delayed rehabilitation, instability, and chronic knee pathologies.[44,45] The actual prevalence of PCL rupture is unknown, perhaps because this injury often remains undiagnosed.[36,79] Published prevalence data vary widely, ranging from 1% to 44%,[19,20,31,58,80] depending on different settings and study populations.[79]

A typical PCL injury mechanism is a blow to the anterior aspect of the tibia from the dashboard of a car during an accident.[79,92] In sports, the PCL may be injured by falling directly on the anterior aspect of the proximal end of the lower leg with a flexed knee or hyperflexion or hyperextension of the knee.[25,92] The diagnosis of a PCL tear is generally made by combining information from the patient history, physical examination, mechanical tests, imaging techniques, and, potentially, arthroscopy.

To our knowledge, there have been no published systematic reviews conducted to determine the diagnostic accuracy of physical examination tests for PCL injuries. Accordingly, the objective of this systematic review was to summarize and evaluate diagnostic accuracy research on clinical tests used for the diagnosis of PCL tears.

## METHODS

### Study Design

The PRISMA guidelines were used throughout the search and reporting phases of this review.[65] PRISMA guidelines are intended to assist in the transparent and complete reporting of systematic reviews and meta-analyses.

### Search Strategy

A comprehensive systematic literature search was conducted using the following databases via the Ovid interface: MEDLINE from 1946, Embase from 1974, and the Allied and Complementary Medicine Database from 1985 until April 30, 2012. The original search strategy was designed

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to identify studies of diagnostic test accuracy for the PCL, as well as for the anterior cruciate ligament (ACL), though only results for the PCL are reported in this review. The terms used for the search strategy were reviewed by 2 experienced orthopaedic surgeons to ensure that all known physical examination tests were included. There was no restriction on selecting studies (eg, language). The search strategy is presented in the **APPENDIX** (online at www.jospt.org). Additionally, the references of all eligible articles of primary diagnostic studies, as well as the references of systematic reviews with similar objectives, were screened.[63,82]

## Inclusion Criteria

All study designs for diagnostic accuracy were considered eligible if they compared the results of physical examination tests performed in the context of a physical examination of the PCL with those of a reference standard. Studies on patients of any age and in any clinical setting were included. We excluded studies if they evaluated physical (index) tests under anesthesia or intraoperatively or postoperatively. Studies on animals and cadavers were also excluded.

Studies that assessed the diagnostic accuracy of physical examination tests to assess a PCL rupture, which was defined as the target condition, were included. PCL rupture could be acute or chronic, as well as partial or complete. The criteria for defining partial and complete tears were those of the originally published studies. Studies were excluded from this systematic review if they did not name or describe a physical examination test or did not reference a source that did. If the name of the physical test was provided by the authors but not described in their study, we assumed that the test was performed in the known manner, and the study was included in the review. Studies were also excluded if they reported the overall accuracy of a group of tests or if the diagnostic accuracy data of individual tests could not be extracted. If authors made use of generic terms, such as *physical examination*, to denote an unspecified combination of physical tests, these studies were also excluded.

To confirm the diagnosis, arthroscopy, arthrotomy, and magnetic resonance imaging (MRI) were used as reference standards. MRI was considered a valid reference standard because recent literature has shown excellent correlation between MRI and arthroscopic as well as arthrotomy findings for the diagnosis of PCL injuries.[23,26,34,47,59,86]

## Selection of Studies and Data Abstraction

Titles and abstracts of studies identified by the search were screened independently by 2 reviewers (C.K. and A.F.). Any disagreements were resolved in discussion between them. To increase the quality of the screening, the 2 reviewers screened the first 100 titles/abstracts, then assessed their agreement level and resolved any disagreements by discussion. After the reasons for disagreement were resolved, the reviewers screened all 1307 titles/abstracts (including the first 100). Subsequently, the full text of the articles was independently assessed for eligibility by the 2 reviewers. Full-text articles that did not fulfill the predefined criteria were excluded, and all disagreements were resolved in consensus meetings.

Study characteristics of each study were independently extracted using standardized and beta-tested evidence tables by the 2 reviewers (C.K. and A.F.). Extracted data included, for example, the study design, type of index test(s), type of reference test(s), and the necessary data for reconstruction of diagnostic 2-by-2 tables. In the event that values were missing, the authors attempted to contact the corresponding authors of the study by e-mail. If missing values could not be obtained, the diagnostic 2-by-2 tables were reconstructed, if possible.

## Assessment of Methodological Quality

Quality assessment of each selected study was performed independently by the 2 reviewers (C.K. and A.F.) using the revised tool for the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2).[90] The QUADAS-2 is a redesigned and improved version of the QUADAS[88,91] that comprises 4 domains: patient selection, index test, reference standard, and flow and timing. Risk of bias is assessed for each domain and, for the first 3 domains, a statement on concerns regarding applicability is given. Each key domain has a set of signaling questions to evaluate the risk of bias and concerns regarding applicability. Signaling questions are answered as "yes," "no," or "unclear." Risk of bias is rated as "low risk of bias," "high risk of bias," or "unclear risk of bias." Concerns regarding applicability are rated as "low," "high," or "unclear." As recommended, to improve reliability, specific guidance on how to assess each signaling question and how to use this information to evaluate the risk of bias was defined[90] and subsequently practiced by the 2 reviewers on a study that was not included in the review. This procedure has also previously been recommended for the use of the QUADAS.[37,73,91] During this testing phase, 1 signaling question from the index test domain of the QUADAS-2 tool ("If a threshold was used, was it prespecified?")[90] was omitted and replaced by 1 question from the original QUADAS tool ("Was the execution of the index test described in sufficient detail to permit replication of the test?").[88] Additionally, the signaling question "Was a case-control design avoided?" was skipped if the study only included patients and therefore reported only the sensitivity of a test. Even if those patients were included consecutively (eg, if scheduled for arthroscopy), a positive answer would be misleading, because studies only reporting sensitivity (or specificity) might be flawed. Disagreement between the 2 reviewers was resolved by consensus within the whole team of authors. As recommended for the QUADAS-2 and QUADAS, we did not make a summary score of the items from the QUADAS tool.[73,87,90] Instead, we categorized the included studies as having a "high," "moderate," or "low" overall risk

of bias. Criteria for this procedure were adopted and slightly modified from the work by Hegedus and colleagues.[32] The results of methodological assessment were presented using tables from the QUADAS-2 website (http://www.bris.ac.uk/quadas/quadas-2/).

### Data Synthesis

We constructed 2-by-2 tables (true positive [*a*], false positive [*b*], false negative [*c*], and true negative [*d*]) that cross-classified the disease status (as determined by the reference test) and the index test's outcome for each index test evaluated in the included studies. For each physical examination test, we calculated, if possible, the sensitivity, specificity, positive likelihood ratio (+LR), and negative likelihood ratio (–LR), including the 95% confidence interval (CI).

Sensitivity is the percentage of positive test results in individuals with the pathology, whereas specificity is the percentage of negative test results in individuals without the pathology. A +LR is the ratio of a positive test result of the people with the pathology to a positive test result in people without the pathology. A –LR is the ratio of a negative test result of the people with the pathology to a negative test result in people without the pathology. A +LR greater than 10 and a –LR less than 0.1 have a large, often conclusive shift on posttest probability and therefore reflect tests that have a large influence on clinical decision making.[43]

Agreement among reviewers of title and abstract screening and methodological assessment using the QUADAS-2 was measured using the Cohen kappa statistic (95% CI). A kappa value of less than 0.20 is considered poor, from 0.21 to 0.40 fair, from 0.41 to 0.60 moderate, from 0.61 to 0.80 strong, and of greater than 0.80 close to perfect agreement.[50] All statistical analyses were performed using R Version 3.0.1 (The R Project for Statistical Computing, Vienna, Austria) and RStudio (RStudio, Inc, Boston, MA).

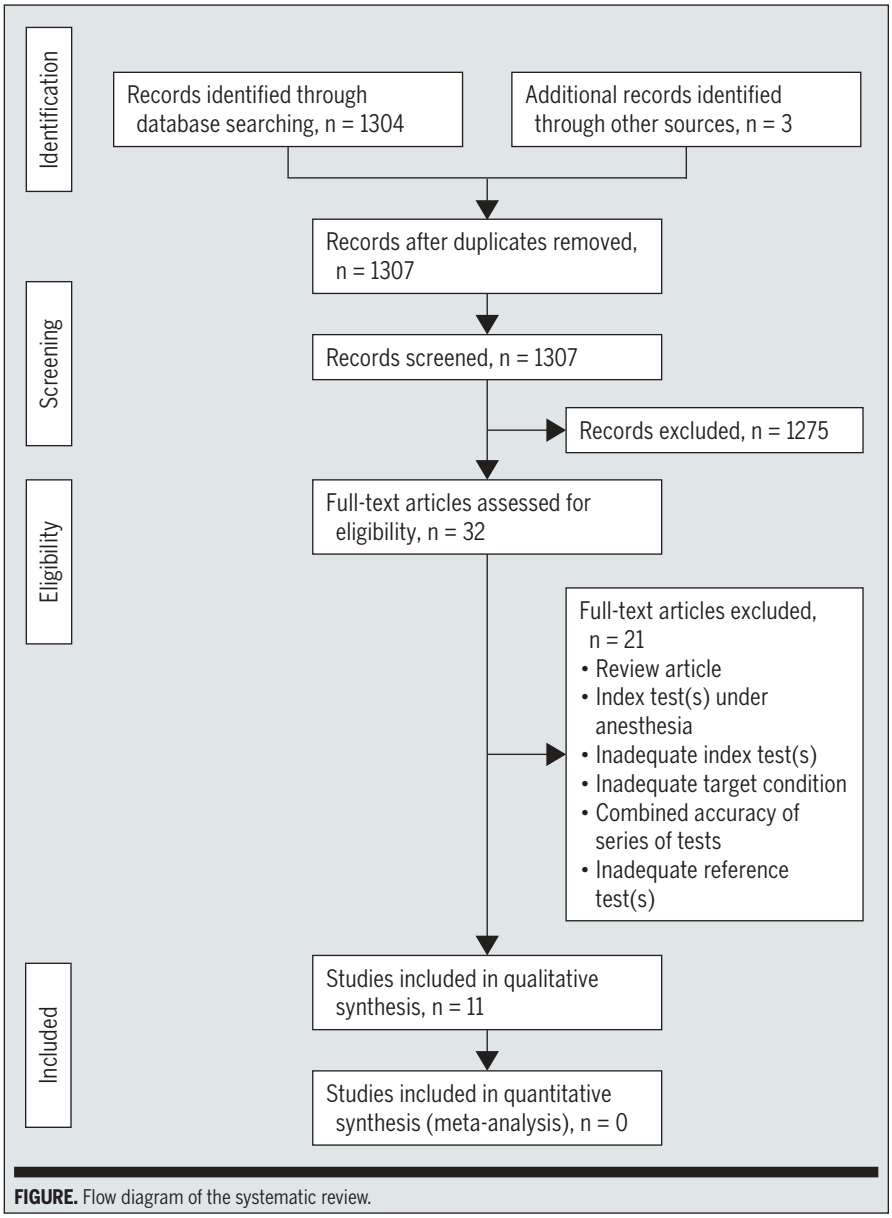


**FIGURE.** Flow diagram of the systematic review.

## RESULTS

### Study Selection

The **FIGURE** summarizes the results of the systematic search and study selection as described in the PRISMA statement.[65] After evaluation of the 1304 search hits (and 3 additional records identified through other sources), only 32 publications met the predefined inclusion/exclusion criteria, of which 12 papers focused on the PCL[4,12,14,21,22,38,41,51,53,60,72,83] and 17 assessed both the PCL and ACL.[2,5-7,11,15,17,28-30,39,40,54,69,74,77,93] These studies were considered appropriate for answering the research question and were retrieved and checked for eligibility. Agreement among reviewers regarding screening of titles and abstracts yielded a Cohen kappa of 0.70 (95% CI: 0.61, 0.80). Eleven of the 32 studies were included for the review.[2,4,12,14,25,29,39,61,67,74,83]

### Methodological Quality

Details on study characteristics are provided in **TABLE 1**. Diagnostic studies are

**TABLE 1** Characteristics of Included Studies

| | | | Population | | Examiner | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Study** | **Study Design** | **Setting** | **Size** | **Age, y*** | **Profession** | **Clinical Experience** | **Index Test** | **Reference Standard** | **Risk of Bias†** |
| Anderson and Lipscomb[2] | Cohort-type accuracy study | Tertiary | 50 | 19.8 | NA | "Experienced surgeon"; no further information | Posterior drawer test | Arthroscopy, arthrotomy | High |
| Baker et al[4] | Cohort-type accuracy study | Tertiary | 7 | 26 (19-41) | NA | NA | Posterior drawer test, varus/valgus test at 0° | Arthrotomy | High |
| Clendenin et al[12] | Cohort-type accuracy study | Tertiary | 10 | 24 (16-30) | NA | NA | Posterior drawer test, posterior sag sign, valgus test at 0°/30° | Arthroscopy | High |
| Daniel et al[14] | Case-control-type accuracy study | Tertiary | 92 | 15-45 | Physicians | NA | Quadriceps active test | Arthroscopy, arthrotomy | High |
| Fowler and Messieh[25] | Cohort-type accuracy study | Tertiary | 13 | 22 | NA | NA | Posterior drawer test, posterior sag sign | Arthroscopy | High |
| Harilainen[29] | Cohort-type accuracy study | Tertiary | 9 (of 328 cases) | NA | NA | NA | Posterior drawer test | Arthroscopy | High |
| Hughston et al[39] | Retrospective, cohort-type accuracy study | Tertiary | 50 | NA | NA | NA | Posterior drawer test, external recurvatum test, varus/valgus test at 0° | Arthrotomy | High |
| Loos et al[61] | Retrospective, cohort-type accuracy study | Tertiary | 59 (of 102 cases) | 27 (n = 102) | NA | NA | Posterior drawer test, recurvatum test, varus/valgus test at 0° | Arthrotomy | High |
| Moore and Larson[67] | Retrospective, cohort-type accuracy study | Tertiary | 18 | 22.56 (15-43) | NA | NA | Varus/valgus test at 0°/30°, posterior drawer test | Arthrotomy | High |
| Rubinstein et al[74] | Case-control-type accuracy study | Tertiary | 39‡ | 27 (12-47) | Physicians | >5 y | Posterior drawer test, posterior sag sign, reverse Lachman test, dynamic posterior shift, quadriceps active test, reverse Lachman end point, reverse pivot shift, recurvatum test | MRI, arthroscopy | Moderate |
| Staubli and Jakob[83] | Cohort-type accuracy study | Tertiary | 22§ | 32 (16-47) | NA | NA | Posterior sag sign, quadriceps active test | Arthrotomy | Moderate |

*Abbreviations: MRI, magnetic resonance imaging; NA, not available.*
**Values are mean, range, or mean (range).*
*†From the revised version of the Quality Assessment of Diagnostic Accuracy Studies tool. Bias: high, score of high risk of bias in 3 or 4 of total of 4 categories or score of high risk of bias in 2 and score of unclear risk of bias in 2 of total of 4 categories; moderate, score of high risk of bias in 2 of total of 4 categories; low, score of high risk of bias in 0 or 1 of total of 4 categories. The 4 categories are (1) patient selection, (2) index test, (3) reference standard, and (4) flow and timing.*
*‡Out of 39 persons, 75 knees were examined. Those 75 examined knees were the basis for further data analysis.*
*§Out of 22 persons, 24 knees were examined. Those 24 examined knees were the basis for further data analysis.*



primarily cross-sectional studies and therefore labeled as case-control-type or cohort-type accuracy studies to avoid confusion regarding the epidemiologic definitions of case-control or cohort studies, respectively.[76] Of the 11 studies included, 2 were case-control-type accuracy studies[14,74] and 9 were cohort-type accuracy studies.[2,4,12,25,29,39,61,67,83] None of the included studies were conducted in a primary-care population. The prevalence (which could be taken as prior probability of PCL rupture in the population in the study) varied widely between 0.03% and 100%. The size of the study population also varied widely, ranging from 7 to 92 subjects.

Results of the quality assessment for individual studies are presented in **TABLE 2**. Agreement among reviewers regarding the overall rating of methodological quality of each study, using the QUADAS-2, yielded a Cohen kappa of 0.82 (95% CI: 0.73, 0.91). Included studies consistently demonstrated a high degree of applicability for the categories index test and reference standard, and a low degree of applicability regarding patient selection. The majority of included studies demonstrated significant method-

**TABLE 2** Quality Assessment Summary: Review Authors' Judgments About Risk of Bias and Applicability Concerns for Each Included Study

| | Risk of Bias | | | | Applicability Concerns | | |
|---|---|---|---|---|---|---|---|
| Study | Patient Selection | Index Test | Reference Standard | Flow and Timing | Patient Selection | Index Test | Reference Standard |
| Anderson and Lipscomb[2] | H | U | H | H | H | L | L |
| Baker et al[4] | H | U | H | H | H | L | L |
| Clendenin et al[12] | H | U | H | H | H | L | L |
| Daniel et al[14] | H | H | L | H | H | L | L |
| Fowler and Messieh[25] | H | H | H | H | H | L | L |
| Harilainen[29] | H | H | H | H | H | L | L |
| Hughston et al[39] | H | U | H | H | H | L | L |
| Loos et al[61] | H | U | H | H | H | L | L |
| Moore and Larson[67] | H | U | H | H | H | L | L |
| Rubinstein et al[74] | H | H | L | U | H | L | L |
| Staubli and Jakob[83] | H | H | L | U | H | L | L |

*Abbreviations: H, high risk; L, low risk; U, unclear risk.*



ological weaknesses, with a high risk of bias for patient selection and flow and timing. The concern for bias in the reference standard was most often due to a failure to use a double-blind design. There were often insufficient data available to judge the risk for bias in the index test(s). In the majority of included studies, there was an inability to reconstruct 2-by-2 tables from the data reported in the original articles, and therefore the risk for bias in the flow and timing was judged as being high. Last, the concern for applicability as it relates to patient selection was due to most studies having included patients scheduled for arthroscopy or patients with known disease and healthy controls.

### Physical Examination Tests

A total of 11 different physical examination tests were evaluated: posterior drawer test, quadriceps active test, recurvatum test, posterior sag sign, varus/valgus test at 0°, reverse Lachman test, dynamic posterior shift, reverse pivot shift, reverse Lachman end point, and valgus and varus tests at 30° of flexion. These tests were compared to an accepted reference standard in all included studies. Values for sensitivity, specificity, +LR, and −LR (95% CI) are shown, where possible, in **TABLE 3.** Results for sensitivity and specificity of physical examination tests were heterogeneous, which was statistically significant (visually assessed using forest plots and statistically using chi-square tests [plots/data not shown]; $\alpha = .05$). Reliability was not assessed in any of the included studies; therefore, no values were available for reporting.

The posterior drawer test was the most frequently studied test, with sensitivity data reported in 8 studies[4,12,25,29,39,61,67,74] and specificity data in only 1 study.[74] The quadriceps active test seemed to be the most specific of the evaluated tests, although only 3 studies evaluated this test,[14,74,83] with 2 of the 3 studies reporting the data needed to calculate specificity and all 3 studies to calculate sensitivity. The values for sensitivity and specificity (95% CI) are shown in **TABLE 3.** The posterior sag sign was evaluated in 5 studies and seemed to be the most sensitive physical examination test.[12,25,61,74,83] However, data to calculate specificity were only available from a single study[74] (**TABLE 3**).

## DISCUSSION

Numerous physical examination tests for the diagnosis of PCL injuries are described in the literature, but, to our knowledge, this is the first systematic review summarizing research on the diagnostic accuracy of those tests. Overall, there is a lack of high-quality diagnostic accuracy studies for those tests, with a high risk of bias of existing studies regarding patient selection, index tests and reference standards, and flow and timing.

Because studies that use retrospective data collection or do not include patients in a consecutive manner are associated with an overestimation of diagnostic test characteristics,[75] most of the included studies seem to be biased in the form of spectrum bias. In addition, case-control-type accuracy studies create a preselected patient population, which contributes to the existence of a spectrum bias. The reason is that included cases and controls are easier to distinguish because of the marked difference between disease and health status.[75,76] With this in consideration, the results from the 2 case-control-type accuracy studies[14,74] should be interpreted with caution. Leeflang et al[56] stated that prevalence may impact specificity and sensitivity, such that higher disease prevalence (eg, in tertiary care) may increase sensitivity, even if this is less relevant in the case of dichotomous tests. Because most of the included studies

**TABLE 3** Diagnostic Accuracy of Physical Examination Tests for Posterior Cruciate Ligament Injury*

| Test or Sign/Study | Sensitivity† | Specificity† | +LR† | −LR† | Risk of Bias‡ |
|---|---|---|---|---|---|
| Posterior drawer test | | | | | |
| Baker et al[4] | 0.86 (0.42, 1.00) | NA | NA | NA | High |
| Clendenin et al[12] | 1.00 (0.69, 1.00) | NA | NA | NA | High |
| Fowler and Messieh[25] | 1.00 (0.75, 1.00) | NA | NA | NA | High |
| Harilainen[29] | 0.33 (0.07, 0.70) | NA | NA | NA | High |
| Hughston et al[39] | 0.22 (0.06, 0.48) | NA | NA | NA | High |
| Loos et al[61] | 0.51 (0.37, 0.64) | NA | NA | NA | High |
| Moore and Larson[67] | 0.67 (0.41, 0.87) | NA | NA | NA | High |
| Rubinstein et al[74] | 0.89 (0.67, 0.99) | 0.98 (0.90, 1.00) | 50.11 (7.14, 351.65) | 0.11 (0.03, 0.40) | Moderate |
| Quadriceps active test | | | | | |
| Daniel et al[14] | 0.98 (0.87, 1.00) | 1.00 (0.93, 1.00) | 98.44 (6.24, 1553.46) | 0.04 (0.01, 0.17) | High |
| Rubinstein et al[74] | 0.53 (0.29, 0.76) | 0.96 (0.88, 1.00) | 11.97 (3.32, 43.13) | 0.50 (0.31, 0.79) | Moderate |
| Staubli and Jakob[83] | 0.75 (0.53, 0.90) | NA | NA | NA | Moderate |
| Recurvatum test | | | | | |
| Hughston et al[39] | 0.39 (0.17, 0.64) | NA | NA | NA | High |
| Loos et al[61] | 0.22 (0.12, 0.35) | NA | NA | NA | High |
| Rubinstein et al[74] | 0.32 (0.13, 0.57) | 0.98 (0.90, 1.00) | 17.68 (2.27, 137.65) | 0.70 (0.51, 0.95) | Moderate |
| Posterior sag sign | | | | | |
| Clendenin et al[12] | 0.90 (0.55, 1.00) | NA | NA | NA | High |
| Fowler and Messieh[25] | 1.00 (0.75, 1.00) | NA | NA | NA | High |
| Loos et al[61] | 0.46 (0.33, 0.59) | NA | NA | NA | High |
| Rubinstein et al[74] | 0.79 (0.54, 0.94) | 1.00 (0.95, 1.00) | 88.35 (5.54, 1409.54) | 0.28 (0.10, 0.51) | Moderate |
| Staubli and Jakob[83] | 0.83 (0.63, 0.95) | NA | NA | NA | Moderate |

*Table continues on page 810.*



had high prevalence rates, the observed results regarding the sensitivity of the validated index tests might be biased.

Studies reporting only the sensitivity or specificity of a physical examination test were included in this systematic review as well, but results from such studies should be interpreted even more cautiously than results from case-control-type accuracy studies. The results from such studies may be flawed because sensitivity and specificity may be inversely proportional to each other. Therefore, a test with nearly perfect sensitivity can easily have insufficient specificity (or vice versa). The methodological assessment using the QUADAS-2 revealed the insufficient methodological quality of those studies with a study population consisting only of patients with the target disorder (eg, patients scheduled for arthroscopy). Another problem with studies reporting only the sensitivity or specificity of a test is that calculation of likelihood ratios is impossible, which limits the clinical utility because clinicians are not able to calculate posttest probabilities.

Additionally, the assessment using the QUADAS-2 revealed a high risk of bias of included studies concerning the blinding of index test results as well as reference standard results. The lack of blinding is a problem in diagnostic test accuracy,[66] and should carefully be assessed. This is highlighted by a recently published review of physical examination tests for the ACL by van Eck et al,[85] who observed a clear increase in sensitivity when there was no blinding of the reference standard results. Because all included studies were conducted before the STARD guidelines were published,[8-10] the methodological quality of included studies might have been judged to have been better, because the reporting of included studies was not accurate and complete as recommended by the STARD initiative.

Based on our results, the quadriceps active test seems to be the most specific and the posterior sag sign the most sensitive test to be used to help in the diagnosis of a potential PCL injury. However, both tests are evaluated in only a few studies of insufficient methodological quality. In particular, the 2 case-control-type studies[14,74] may overestimate the test characteristics of these 2 tests.

Although the posterior drawer test was the most frequently evaluated physical examination test for assessing the PCL, results regarding the sensitivity of the test are heterogeneous, and results for specificity could only be obtained from 1 case-control-type accuracy study.[74] Therefore, at this stage, determining the value of the posterior drawer test is difficult.

**TABLE 3** Diagnostic Accuracy of Physical Examination Tests for Posterior Cruciate Ligament Injury* (continued)

| Test or Sign/Study | Sensitivity† | Specificity† | +LR† | −LR† | Risk of Bias‡ |
|---|---|---|---|---|---|
| Varus/valgus at 0° | | | | | |
| Baker et al[4] | 0.43 (0.10, 0.82) | NA | NA | NA | High |
| Hughston et al[39] | 0.94 (0.73, 1.00) | 1.00 (0.89, 1.00) | 60.79 (3.87, 954.79) | 0.08 (0.02, 0.37) | High |
| Loos et al[61] | 0.59 (0.46, 0.72) | NA | NA | NA | High |
| Moore and Larson[67] | 0.28 (0.12, 0.49) | NA | NA | NA | High |
| Reverse Lachman test | | | | | |
| Rubinstein et al[74] | 0.63 (0.41, 0.81) | 0.89 (0.79, 0.95) | 5.90 (2.57, 13.55) | 0.41 (0.28, 0.75) | Moderate |
| Dynamic posterior shift | | | | | |
| Rubinstein et al[74] | 0.58 (0.36, 0.77) | 0.95 (0.85, 0.98) | 10.81 (3.37, 34.67) | 0.45 (0.26, 0.76) | Moderate |
| Reverse pivot shift | | | | | |
| Fowler and Messieh[25] | 0.19 (0.04, 0.46) | NA | NA | NA | High |
| Rubinstein et al[74] | 0.26 (0.12, 0.49) | 0.95 (0.85, 0.98) | 4.91 (1.30, 18.64) | 0.78 (0.59, 1.03) | Moderate |
| Reverse Lachman end point | | | | | |
| Rubinstein et al[74] | 0.63 (0.41, 0.81) | 0.89 (0.79, 0.95) | 5.90 (2.57, 13.55) | 0.41 (0.23, 0.75) | Moderate |
| Valgus at 30° | | | | | |
| Clendenin et al[12] | 0.20 (0.03, 0.56) | NA | NA | NA | High |
| Moore and Larson[67] | 0.78 (0.52, 0.94) | NA | NA | NA | High |
| Varus at 30° | | | | | |
| Clendenin et al[12] | 0.00 (0.00, 0.31) | NA | NA | NA | High |
| Moore and Larson[67] | 0.17 (0.04, 0.41) | NA | NA | NA | High |

*Abbreviations: −LR, negative likelihood ratio; +LR, positive likelihood ratio; NA, not available.*
**None of the studies provided reliability data.*
*†Values in parentheses are 95% confidence interval.*
*‡From the revised version of the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2). Bias: high, score of high risk of bias in 3 or 4 of total of 4 categories or score of high risk of bias in 2 and score of unclear risk of bias in 2 of total of 4 categories; moderate, score of high risk of bias in 2 of total of 4 categories; low, score of high risk of bias in 0 or 1 of total of 4 categories. The 4 categories are (1) patient selection, (2) index test, (3) reference standard, and (4) flow and timing.*



Evidence is lacking for the diagnostic accuracy of the varus/valgus test at 0° and 30° in assessing the PCL. Certainly, those tests have been shown to have value in the diagnosis of medial and lateral collateral ligament injuries.[46,81] For some of the identified physical examination tests, there is only anecdotal evidence of their value in making a diagnosis. To date, many previously described tests have not been investigated for their diagnostic accuracy: the proximal tibial percussion test,[21] fixed posterior subluxation,[84] posterior functional drawer test,[21] Loomer test,[60] dial test,[1,52] as well as the standing apprehension test.[22]

Combining the results of several physical examination tests has the potential to increase diagnostic accuracy.[18,42,71,81] But these studies were not included in this review because they reported diagnostic accuracy based on a combination of tests. The combination of tests to achieve the best possible diagnostic accuracy is unknown. Furthermore, the influence of knowledge of injury mechanism, symptoms, and other patient-related facts on the accuracy of the diagnosis should be evaluated in the context of diagnostic test research in the future.

In this systematic review, studies evaluating physical (index) tests under anesthesia, or intraoperatively or postoperatively, were excluded. One could argue that the physical examination of PCL injuries, particularly in acute conditions, is difficult to perform without anesthesia. However, we aimed to study whether the physical examination without anesthesia might be sufficient so that examination under anesthesia could be avoided, as such evaluation may be associated with risks for the patient. Because of this selection criterion, 4 studies were excluded from this review.[15,38,51,77]

Another point of contention is the choice of an adequate reference standard, because, in most cases, a perfect reference standard is not possible.[48,49] Arthrotomy, arthroscopy, and MRI were defined as reference standards in this review. MRI has an excellent correlation with arthroscopic and arthrotomy findings and is considered valid and reliable.[23,26,34,47,59,70,86,92] We are aware that reference standards might misclassify some cases; for example, MRI could be

a false negative if the PCL healed spontaneously.[92] Even the arthroscopic examination might be a false negative in such a case, but a more careful examination might detect abnormal contact between the medial femoral condyle and the anterior portion of the meniscus as a sign of a posterior shift of the proximal tibia, or erroneously detect positive signs for ACL laxity, which may indicate a former PCL rupture with residual laxity.[55] We first considered stress radiography (eg, TELOS device; Telos GmbH, Marburg, Germany) as another possible reference standard but decided against this method because the most valid method of stress radiography has yet to be determined, although stress radiography, especially for a chronic PCL rupture, has been shown to have some value and may in fact be superior to evaluation using a KT arthrometer (MEDmetric Corporation, San Diego, CA).[35,62,64]

Searching for diagnostic test accuracy studies can be much more difficult than searching for intervention studies. Leeflang et al[57] stated that a clear, unequivocal key word or indexing term is missing in the context of database searches. Also, the medical subject heading "sensitivity and specificity" might be applied inconsistently,[57] and the use of filters is under debate and currently not recommended by the Cochrane Library.[16] Therefore, we avoided the use of medical subject heading terms and instead used the .MP field in the Ovid databases.[68] This procedure was adopted from a published diagnostic test accuracy protocol from the Cochrane Library in the context of physical examination of the shoulder.[27] We performed our electronic literature search in 3 databases (MEDLINE, Embase, Allied and Complementary Medicine Database), consistent with recommendations to search in more than just 1 database for diagnostic test accuracy studies.[16,89] We decided not to search within PEDro, in contrast to authors of other diagnostic test accuracy reviews,[13,78] because this database contains few diagnostic studies.[33] On the basis of the aforementioned reasons, we are confident that all relevant articles on this issue have been identified.

Initially, we planned a meta-analysis, but this was not possible due to the small number and heterogeneity of the included studies. Heterogeneity might have been caused by a number of sources, for example, different patient populations, study design, missing description of index tests, or lack of blinding. Because no meta-analysis was performed, we could not investigate the influence of covariates.

Given the limitations of all the reviewed studies, there is a strong need for sound research of high methodological quality in this area. Future studies should follow the recommendations of the STARD initiative.[8-10] STARD aims to improve the accuracy and completeness of reporting of studies of diagnostic accuracy, and therefore helps to assess the potential for bias of diagnostic test accuracy studies and to evaluate the generalizability.

### Limitations

Most of the included studies were not performed recently, and there is a lack of similar studies published in the more recent literature. Most of the included studies provided data solely to calculate sensitivity; therefore, the calculation of specificity was not always possible. A meta-analysis could not be performed because of the low number of included studies and their heterogeneity, which also prevented a subgroup analysis, a common problem in the context of diagnostic test accuracy studies.[3] Consistent with the recommendation for adequate sample sizes for diagnostic test accuracy studies given by Flahault et al,[24] all included studies were underpowered.

## CONCLUSION

Based on our results, the quadriceps active test seems to be the most specific test and the posterior sag sign the most sensitive test to help in the diagnosis of a potential PCL injury, although this conclusion is based on a few studies of low methodological quality. Presently, most physical examination tests have not been evaluated sufficiently, and, at this stage, determining the most appropriate tests for assessing the integrity of the PCL is difficult. Thus, there is a strong need for further research in this area. ◉

### KEY POINTS

**FINDINGS:** Presently, most physical examination tests have not been evaluated sufficiently, and, at this stage, determining the most appropriate tests for assessing the integrity of the PCL is difficult.

**IMPLICATIONS:** There is a strong need for sound research of high methodological quality to establish the diagnostic accuracy of clinical examination tests to help in the accurate diagnosis of a potential PCL injury.

**CAUTION:** Many of the studies included in this review were prone to bias, and their design is likely to overestimate test characteristics.

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## APPENDIX

### SEARCH STRATEGY

1. Diagnos$.mp.
2. Examin$.mp.
3. Man?euv$.mp.
4. Sign$.mp.
5. Test$.mp.
6. Or/1-5
7. Lachman$.mp.
8. Active lachman$.mp.
9. Anterior drawer.mp.
10. Pivot shift.mp.
11. Fibular head.mp.
12. Posterior drawer.mp.
13. Posterior sag.mp.
14. Godfrey$.mp.
15. Quadriceps active.mp.
16. Reverse pivot shift.mp.
17. Reverse lachman$.mp.
18. Trillat$.mp.
19. Varus instability.mp.
20. Valgus instability.mp.
21. External rotation recurvatum.mp.
22. Fixed posterior subluxation.mp.
23. Proximal tibial percussion.mp.
24. Posterior functional drawer.mp.
25. Modified posterolateral drawer.mp.
26. Loomer$.mp.
27. Posterolateral rotation.mp.
28. Dial.mp.
29. Posterolateral drawer.mp.
30. Standing apprehension.mp.
31. Or/7-30
32. And/6,31
33. Patholog$.mp.
34. Ruptur$.mp.
35. Lesion$.mp.
36. Torn.mp.
37. Tear$.mp.
38. Effusion$.mp.
39. Laxity.mp.
40. Instability.mp.
41. Or/33-40
42. Knee.mp.
43. Anterior cruciate ligament.mp.
44. ACL.mp.
45. Posterior cruciate ligament.mp.
46. PCL.mp.
47. Or/42-46
48. And/41,47
49. And/32,48
50. Remove duplicates from 49