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Reliability of the Lateral Pull Test and Tilt Test to Assess Patellar Alignment in Subjects with Symptomatic Knees: Student Raters

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Study Design: Test-retest reliability with blinded testers.
Objectives: To determine the inter- and intra-rater reliability of the lateral pull test and patellar tilt test.
Background: If patellar malalignment can be detected by clinical examination, then condition-specific treatment interventions may be implemented in patients with patellofemoral pain syndrome. However, several clinical tests used to assess patellar mobility have recently been shown to have poor to fair reliability. Because the lateral pull test and the patellar tilt test are widely used clinically as diagnostic tests for patellofemoral pain syndrome but have not been previously tested for reliability, we examined these tests.
Methods and Measures: Fifty-two subjects (age range, 21–48 years) provided 95 knees (19 symptomatic and 76 asymptomatic) for assessment of the lateral pull test. Two testers, blinded to the presence or absence of symptoms, independently performed the lateral pull test in random order. Fifty-five subjects (age range, 22–42 years) provided 99 knees (73 asymptomatic and 26 symptomatic) for assessment of the patellar tilt test. Three blinded testers independently performed the patellar tilt test in random order. All subjects were tested and retested within 3–5 days. A kappa (κ) statistic was used to assess the agreement of findings within each tester and between testers.
Results: The kappa coefficients for intrarater reliability varied from 0.39 to 0.47 for the lateral pull test and from 0.44 to 0.50 for the patellar tilt test, while the coefficients for interrater reliability were 0.31 for the lateral pull test and varied from 0.20 to 0.35 for the tilt test.
Conclusions: Repeated lateral pull tests and patellar tilt tests had fair intrarater and poor interrater reliability. Our results suggest that care must be taken in placing too much emphasis on these tests when making clinical decisions. *J Orthop Sports Phys Ther 2001;31:368–374.*

Key Words: *lateral tracking, patellar mobility, patellofemoral alignment, patellofemoral pain syndrome, reliability*

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Patellofemoral pain syndrome (PFPS) is one of the most common musculoskeletal disorders of the knee,[1,25,37] with the incidence in the general population being as high as 1 in 4 and even higher in athletic individuals.[19] PFPS is a condition involving the patella and adjacent retinacular structure that is not attributable to peripatellar bursitis, tendinitis, skeletally immature apophysitis, or internal derangement of the knee.[28] Persons with PFPS commonly report symptoms of aching pain in the retropatellar region, which increases with flexed knee postures such as during squatting, sitting, stair climbing, or athletic activities.[1,19,25,26,28]

The etiology of PFPS is not clear. Several authors report that excessive lateral tilt[5,7,8,19,37] or displacement[7,19,37] of the patella with an associated tight lateral retinaculum ("excessive lateral pressure syndrome") provokes symptomatology. However, not all individuals with PFPS have radiographic evidence of excessive lateral patellar tilt.[10,20,25,32] Other etiologies of PFPS include a shallow intercondylar groove[17,24] and overuse or overactivity of the patellofemoral joint in structurally normal knees.[3,13,21] Quadriceps weakness (specifically, "overpull" by the vastus lateralis muscle in the presence of an atrophic vastus medialis muscle)[9,17,19,37,38] and lower extremity malalignment[17,37,38] have also been implicated as causes of excessive lateral patellar pressure.

The etiology of PFPS is important to clinicians because knowledge of the presumed source of symptoms will direct treatment. For example, if a patient has a tight lateral retinaculum causing excessive lateral pressure, then they may benefit from patellar taping and manual stretching to lengthen the retinaculum and improve patellar alignment.[8,19,37] Interventions to elongate peripatellar connective tissues may not be indicated in individuals who have patellar malalignment secondary to abnormal bony configuration or who have overuse PFPS without evidence of excessive lateral pressure syndrome. Rose suggests that patients should be classified by their specific movement dysfunction in order to direct treatment and to identify equivalent groups for efficacy research.[31]

Wilk et al[37] recently introduced a classification system to direct treatment interventions in the nonoperative management of patellofemoral disorders. In their classification system, patients with PFPS are separated into 8 groups based on the initial examination, which includes tests of patellar joint mobility. The authors point out that additional research is needed to determine if their proposed classification system is valid and reliable, including the testing of the reliability of specific patellar mobility tests used to categorize patients.[37]

Several clinical tests of patellar mobility and position have been scientifically examined, but studies have yet to prove them reliable. The McConnell system of patellar classification has been shown to exhibit poor to fair test-retest intertester reliability in 2 separate studies,[6,36] and it lacks validity in comparison with magnetic resonance imaging.[27] Other manual and instrumented methods of quantifying patellar movement have also demonstrated poor reproducibility.[33,35]

In their recently proposed classification system, Wilk et al suggest that in excessive *lateral* pressure syndrome, "the most critical finding on physical examination is that the patella is tilted laterally, and there is excessive tightness of the lateral retinacular structures when compared with the medial side."[37(p309)] They suggest that individuals with excessive *lateral* pressure syndrome will exhibit diminished passive medial patellar displacement (ie, patellar "glide").[37] Other authors have recommended similar tests of medial and lateral patellar glide.[7,8,12,15,16,22,29,30]

Kolowich et al[16] suggest that physical examination of patellar mobility may be used to classify patients as good or poor candidates for lateral release surgery. Those authors suggest a clinical examination that includes the lateral pull test, patellar tilt test, and patellar glide test to examine patellar tracking and diagnose lateral compression syndrome. The patellar tilt and glide tests are specifically recommended to determine whether or not a patient has a tight lateral restraint and will benefit from surgery.

The patellar tilt,[16] glide,[16,37] and lateral pull test[16] are tests recommended by clinical experts to categorize patients; however, the reliability of these measures is unknown. The purpose of our study was to evaluate the inter- and intra-rater test-retest reliability of 2 clinical tests that are potentially useful in detecting excessive lateral pressure syndrome: the patellar tilt test and the lateral pull test.

METHODS

Subjects

Subjects used to evaluate the lateral pull test were men (n = 15) and women (n = 37) between the ages of 21 and 48 with a mean age of 28 years. These subjects provided 95 knees for evaluation, 19 symptomatic and 76 asymptomatic. Subjects used to evaluate the patellar tilt test were men (n = 22) and women (n = 33) between the ages of 22 and 42 with a mean age of 27.3 years. Subjects in this portion of the study provided 99 knees, 73 asymptomatic and 26 symptomatic.

Using a sample of convenience, nonimpaired subjects included students at the University of Texas Southwestern Allied Health Sciences School and volunteers from the surrounding community. Those with symptomatic knees were recruited from outpatients at the James W. Aston Ambulatory Care Center (n = 4), runners in the Baylor/Tom Landry Marathon Training program (n = 8), and students or community volunteers (n = 33). Prior to participating in this study, each subject signed an informed consent form. This study was approved by the Institutional Review Board at the University of Texas Southwestern Medical Center at Dallas.

Each subject was screened by a designated second-year physical therapy student, who did not participate in the testing process, to determine whether the subject met the inclusion criteria and whether the subject had patellofemoral pain syndrome. There was one screener for subjects examined during investigation of the patellar tilt test and another screener for subjects examined during investigation of the lateral pull test. To be included in the study, subjects were required to have full knee range of motion and to be independent ambulators in the community.

Subjects' knees were excluded if the participant reported any history of traumatic knee or hip injury, surgery, patellar dislocation, or neuromuscular disease. Knees presenting with obvious ligamentous or

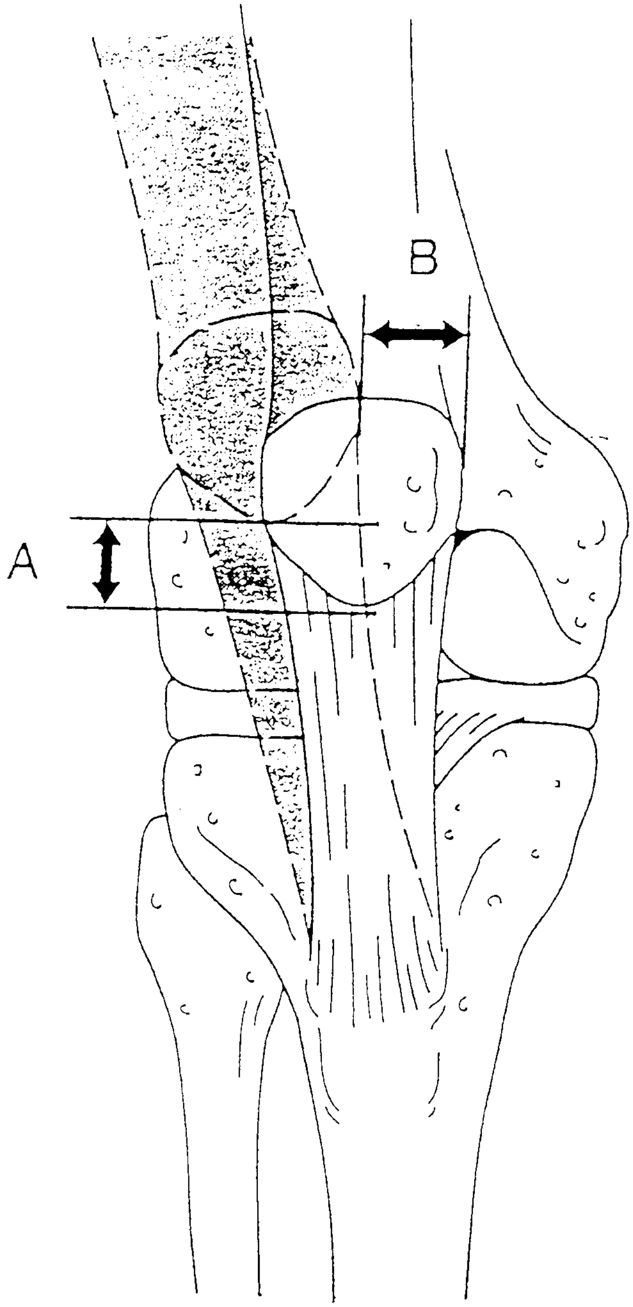

FIGURE 2. The lateral pull test compares the amount of superior (A) versus lateral (B) patellar translation during an active quadriceps femoris muscle contraction. (Reprinted with permission from: Magee DJ. *Orthopedic Physical Therapy.* 3rd Edition. © 1997, W.B. Saunders Company).

TABLE 1. Kappa coefficients and percentage of agreement for intrarater test-retest reliability of the patellar tilt test.

Tester	Kappa	Percent agreement
1	0.50	70%
2	0.47	67%
3	0.44	69%

TABLE 2. Kappa coefficients and percentage of agreement for interrater test-retest reliability of the patellar tilt test.

Testers	Kappa	Percent agreement
1 and 2	0.33*	57%
2 and 3	0.20*	47%
1 and 3	0.35*	62%

* All tests were used in the calculation of kappa for interrater reliability.

chance. (The percentages of agreement and kappa coefficients are summarized in Tables 1–3). Intrarater κ values varied from 0.44 to 0.50 for the patellar tilt test and 0.39 to 0.47 for the lateral pull test. Interrater κ values were 0.31 for the lateral pull test and varied from 0.20 to 0.35 for the patellar tilt test.

Kappa values may be interpreted as follows: <0.40 = poor, ≥ 0.40 to <0.75 = fair to good, and ≥ 0.75 = excellent.[11,18] The kappa coefficients represent the proportion of agreement after accounting for chance agreement, which is particularly important in this study where testers only had 2 or 3 choices and therefore a high random chance of agreement.

To calculate kappa coefficients, the frequencies of testers' agreement and disagreement are plotted in Table 4 for the lateral pull test. In this example, because 95 knees were tested twice to determine intrarater reliability, all of those tests were used in the determination of interrater reliability, providing a total of 190. In Table 4, while testers agreed on their measures of either (+) or (−) lateral pull 118 times, they disagreed 72 times. Thus, the testers agreed 62% of the time. Because there are only 2 categories, chance agreement was removed, leaving a κ of 0.31 (poor agreement).

DISCUSSION

The lateral pull test and patellar tilt test, which have not been previously tested for reliability, had poor interrater agreement. Classifying patients into treatment categories may need to be based on more than clinical tests that involve palpation and visual estimation. Our testers did not feel that it was difficult to detect individuals with severe lateral tracking or patellar tilt, but rather, they had difficulty deciding how to categorize many knees that are borderline between excessive and "normal."

To classify patients with a tight lateral restraint, var-

TABLE 3. Kappa coefficients and percentage of agreement for reliability of the lateral pull test.

	Kappa	Percent agreement
Intrarater 1 (test-retest)	0.47	71%
Intrarater 2 (test-retest)	0.39	77%
Interrater (test-retest)	0.31*	62%

* All tests were used in the calculation of kappa for intertester reliability.

meniscal pathology, major joint effusion, tenderness at the inferior patellar pole (tendinitis), or patellar stuttering during knee extension (plica syndrome) were also excluded.[36] Standard orthopaedic tests[29] were used to rule out the presence of ligamentous (varus/valgus stress tests, Lachman's, and posterior drawer) and meniscal (McMurray's) pathology. A positive result (pain, patellar stuttering, ligamentous laxity, or the presence of joint effusion) on any of these tests resulted in exclusion. Based on the above criteria, 20 knees were excluded.

Each knee (n = 194) was classified by a screener as either symptomatic (PFPS) or asymptomatic. Subjects' knees were considered symptomatic (n = 45) based on self-report of anterior knee pain that was readily reproducible during at least 2 of the following 4 activities within the last month: ascending stairs, descending stairs, prolonged sitting, or squatting.[26,36]

Experimental Procedure

Five senior physical therapy students served as the testers. Three testers evaluated subjects during the first phase of the study (patellar tilt test) and 2 other testers evaluated subjects during the second phase of the study (lateral pull test). These students had completed coursework in musculoskeletal evaluation and management, clinical kinesiology, and gross human anatomy. The testers had also completed 120 hours of clinical education during which direct patient care was required.

Prior to data collection, the testers and screeners practiced the tests with the first author (C.J.W.), who has over 10 years of clinical experience. Coin tosses were used to maintain randomization throughout testing procedures (tester and test order). To avoid bias, the testers remained blinded to the absence or presence of pain in subjects they tested until data collection was complete.

Once a subject was included in the study, the screener placed him or her in the supine position on a treatment plinth with shoes off. The testers alternately entered the room and graded the patellar tilt and lateral pull tests. Subjects were retested within 3–5 days of their initial test using the same procedure.

The patellar tilt test[16] was performed by positioning the subject in supine with the knees extended with instructions to relax the quadriceps muscles throughout the procedure. The tester stabilized the lower extremity in neutral hip rotation at the ankle using one hand. To assess tilt, the tester lifted the lateral edge of the patella from the lateral femoral condyle using the index finger and thumb of the other hand (Figure 1). The patella should remain in the trochlear groove and not be allowed to laterally sublux during the test.[16] Testers categorized subjects' patellae as having either a positive, neutral, or negative

FIGURE 1. To perform the patellar tilt test, the examiner lifts the lateral edge of the patella from the lateral femoral condyle. The patella should remain in the trochlear groove and not be allowed to sublux laterally.

angle with respect to the horizontal. Kolowich et al[16] propose that an excessively tight lateral restraint is demonstrated by a neutral or negative angle to the horizontal.

The lateral pull test was performed with subjects in the same position, with the lower extremity in neutral hip rotation at the ankle. The lateral pull test was assessed by grading the tracking of the patella during an active isometric quadriceps femoris muscle contraction. The tester observed the tracking with and without light palpation of the superior pole of the patella. According to Kolowich et al, "the patella should be pulled in a straight superior direction or superior and lateral in equal proportions" (Figure 2).[16(p362)] The test was scored as follows: a (+) grade was given if the patella tracked more laterally than superiorly and a (−) grade was assigned for superior or equidistant superior and lateral patellar tracking.

Data Analysis

The data for the modified patellar tilt test and lateral pull test are nominal data. The kappa coefficient (κ) is a chance-corrected percentage of agreement measure.[18] Straight percent agreement measures and kappa values were calculated to assess the level of agreement of each tester and between testers.

RESULTS

For both the lateral pull test and the patellar tilt test, testers agreed with their own repeat measures approximately 70% of the time and agreed with each others measures approximately 57% of the time. Percentage of agreement measures for the 2 tests varied from 67 to 77% when a tester was compared with themselves and from 47 to 62% when one tester was compared with another tester.

However, the patellar tilt test and the lateral pull test did not prove to be reliable when corrected for

TABLE 4. Lateral pull test: agreement matrix for testers 1 and 2.

	Tester 1 (+)	Tester 1 (−)	Total
Tester 2 (+)	45	3	48
Tester 2 (−)	69	73	142
Total	114	76	190

(+) indicates the patella actively tracks laterally > superiorly; (−), patella actively tracks superiorly or equidistant superolaterally.

ious authors have suggested the patellar tilt and glide tests. In the first phase of this study, we did not find the tilt test to be reliable. During this phase we also examined the glide test, during which the patella is divided into 4 quadrants and the amount of passive displacement is quantified by number of quadrants.[16] To test reliability of the glide test in that form, however, the sample must include a significant number of subjects with hypermobile (to the point of dislocatable) patellae. Our sample did not possess any subjects with 4 quadrants of passive mobility and, therefore, we could not adequately evaluate the reliability of the test. Future studies of the glide test should either include a number of subjects with dislocatable patellae or revise the way the accessory mobility of the patella is graded.

In the second phase of this study, we investigated the lateral pull test, which may be indicative of a tight lateral restraint, but may also be influenced by abnormal bony configuration of the trochlea, generalized ligamentous laxity or quadriceps weakness. Thus, by itself the lateral pull test may not be useful in discriminating between various etiologies. However, a test which helps the clinician determine if a patient has excessive lateral patellar tracking would be helpful in directing treatment.

To estimate the test-retest reliability of these patellar alignment tests, kappa was used because it corrects for chance agreement. Kappa is generally a preferred statistic to estimate interrater agreement for nominal scale data; however, caution should be used when interpreting kappa if there is an imbalance in the data being assessed. In this situation, the kappa coefficient may be significantly lowered or inflated.[4,6]

If marginal totals in the agreement matrix are symmetrically imbalanced (vertical totals increase from top to bottom and horizontal totals increase from left to right), the kappa will be lowered and will tend to underestimate reliability. The effect of marginal totals on kappa is probably most significant when percent agreement is high. A symmetrical imbalance, in the presence of >70% agreement, did exist in our intrarater data. A symmetric imbalance was present in the agreement matrix of tester 2 during intrarater reliability measurements of the lateral pull test. Thus, the kappa coefficients for the intrarater reliability of tester 2 may have been artificially lowered.

Conversely, if marginal totals are asymmetrically imbalanced (vertical totals increase from top to bottom, horizontal totals decrease from left to right), kappa may be elevated and reliability overestimated.[4,6] An asymmetrical imbalance in the marginal totals was present in the interrater data of the lateral pull test. In Table 4 for example, the horizontal marginal totals decrease from left to right while the vertical marginal totals increase from top to bottom. Thus, kappa for interrater reliability may have been artificially elevated. However, interrater percent agreement for these tests was not high (62%), and therefore our kappa values were probably not seriously affected.[6]

A reliable clinical measure of passive patellar mobility to assess the length of noncontractile lateral restraints remains elusive. The ability of our testers to classify dynamic patellar motion as either normal or excessive was also limited. Why is patellar mobility so difficult to measure with consistency? Generally, the primary sources of inconsistency in clinical measures are the attribute being measured, the measurement itself, and the measurer.[14] The first problem is that the attribute being measured in this study, patellar mobility, lacks normative data. Without a universal definition of normal, it is of course difficult to identify abnormal. Even experts disagree about what is normal versus abnormal patellar mobility. For example, Kolowich et al[16] consider a patient with medial patellar glide of one quadrant to be a good surgical candidate, while Wilk et al[37] describe one quadrant of patellar displacement as normal.

The second potential source of inconsistency is the intrinsic problems associated with patellar tests. During the patellar tilt and lateral pull tests, the nonplanar shape of the patella and the varying amounts of suprapatellar tissue among the subjects may have made it difficult to palpate and visually locate the patella. The patellar tilt test is a manual test of joint mobility during which testers apply a force to tilt the patella medially, while stabilizing it from gliding laterally. The amount of external force used to move joints and to stretch tissues is poorly documented and needs further investigation.[34] In a pilot study, Threlkeld[34] recorded the external forces produced by 2 experienced physical therapists performing various grades of thoracic spine mobilization and reported a large disparity between the therapists. Similarly, testers in this study felt that it was difficult to quantify the amount of force to use with their hands when performing passive patellar tilt.

The final source of inconsistency, the measurer, may be a factor in this investigation because the testers were senior physical therapy students. While it should be noted that these students received a significant amount of training, their skills may not be reflective of most experienced clinicians who currently employ these tests. It appears that several sources of inconsistency confound the clinical examination of patellar mobility. These reasons may explain, in part, why current clinical tests have not been proven reliable.

Individual tests commonly used to identify sacroiliac dysfunction have also been shown to have questionable reliability,[23] indicating again that individual tests of patellar mobility may not be the answer. However, Cibulka et al[2] demonstrated that by combining the results of 4 different tests to confirm or deny the presence of sacroiliac dysfunction, the interrater reliability was excellent ($\kappa = 0.88$). Perhaps clusters of tests that classify patients with PFPS into subgroups would increase interrater reliability.

It is also possible that patellar mobility/tracking impairments are not the only data that should be considered when classifying individuals with PFPS. Perhaps the pain complaints and functional limitations of various subgroups of individuals with PFPS would be useful to clinicians who are trying to classify patients. It would be interesting to compare the pain complaints and functional limitations of different samples of patients with PFPS (those who have excessive lateral tracking due to abnormal bony configuration of the trochlea, those who have excessive lateral tracking but do not have abnormal bony configuration of the trochlea, and those who do not have excessive lateral patellar tracking) using kinematic magnetic resonance imaging. If the groups differ significantly, then perhaps a combination of the subjective ratings, functional limitations, and a cluster of patellar static/dynamic mobility tests would prove valuable in classifying the clinical impairments of these individuals.

CONCLUSIONS

Our study tested the intra- and inter-rater reliability of the lateral pull test and modified patellar tilt test as clinical tests used to evaluate patellar mobility. The lateral pull test and the patellar tilt test did not prove to be reliable for student raters. Clinicians should exercise caution when making treatment decisions based on clinical measures of patellar mobility until better reliability is established. Further research is needed to establish a reliable and valid system of classifying individuals with PFPS to direct surgical and conservative management.

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