Reliability of Measurements Obtained With Four Tests for Patellofemoral Alignment

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Background and Purpose. *A series of patellofemoral (PF) alignment tests have been described that are used to determine when and how PF taping techniques should be applied. The reliability of measurements obtained with these tests has not been reported. The purpose of this study was to determine the intertester reliability of measurements obtained with four PF alignment tests: medial/lateral displacement, medial/lateral tilt, medial/lateral rotation, and anterior tilt.* ***Subjects.*** *Twelve physical therapists from four clinics served as testers. A total of 66 patients were evaluated.* ***Methods.*** *Paired testers performed all four PF alignment tests on the same patient. The intertester reliability of judgments for each of the PF alignment tests was determined by a kappa correlation coefficient.* ***Results.*** *Kappa correlation coefficients ranged from .10 to .36 for the four PF alignment tests.* ***Conclusion and Discussion.*** *These findings suggest that the reliability of measurements obtained with the PF alignment tests described in this report ranged from poor to fair. Potential factors affecting the reliability of these measurements are discussed. Alternative methods for deciding when and how to apply PF taping techniques are also discussed. [Fitzgerald GK, McClure PW. Reliability of measurements obtained with four tests for patellofemoral alignment. Phys Ther. 1995;75:84–92.]*

Key Words: *Patellofemoral joint, Patellofemoral malalignment, Reliability.*

The term "patellofemoral (PF) malalignment" implies that there is a disruption in the normal tracking of the patella in the femoral groove during knee motion.[1] This condition may result in abnormal stresses being applied to structures associated with the PF joint, producing pain and inflammation. A number of physical therapy interventions have been described for PF malalignment, all of which emphasize reducing factors that may contribute to the malalignment.[1–7]

McConnell[4] has described a series of tests for determining PF alignment. These tests examine the presence or absence of medial/lateral displacement, medial/lateral tilt, medial/lateral rotation, and anterior tilting of the patella with respect to the femur. The results of the tests are used to assist the therapist in making treatment decisions regarding PF taping techniques and therapeutic exercise procedures, which are also described by McConnell.[4]

The reliability of measurements obtained with the PF alignment tests described by McConnell[4] has not been reported. A preliminary investigation performed by the first author (GKF) on 30 subjects, with and without PF pain, suggested that intratester reliability of these measurements was poor. If the reliability of measurements obtained with this evaluation procedure are poor, clinical decisions that are

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Table 1. *Characteristics of Testers*

Clinic	Knee Disorders[a] Case Load (%)	Patients Examined[b]	Therapist No. (Years of Experience)[c]
A	60	19	1 (4.5)
			2 (1.5)
B	20	13	1 (7.0)
			2 (19.0)
			3 (9.0)
C	25	22	1 (17.0)
			2 (1.5)
			3 (10.0)
			4 (1.5)
D	20	12	1 (4.5)
			2 (7.5)
			3 (9.0)

[a]Percentage of the therapists' case loads that comprised patients with knee disorders.

[b]The number of patients examined for this study from each clinic.

[c]The experience (in years) of each therapist treating patients with knee disorders.

made based on this procedure may not be valid.

A number of consequences may result from selecting treatment for PF dysfunction from unreliable measurements of PF alignment. For example, if PF taping techniques are selected based on unreliable measurements, the treatment may not be effective. Taping may then be incorrectly dismissed as an ineffective treatment for a patient who may be helped by a different taping technique. Unreliable measurements of alignment may also lead to a false impression about the mechanism involved if taping is successful in relieving symptoms. For example, suppose we have concluded that our patient has an excessive lateral displacement of the patella based on our examination of alignment. If the measurement is unreliable, there is a chance that perhaps the patella is not displaced or displaced medially. Nevertheless, we would select a taping technique for a lateral displacement. If our patient's condition improves, we may assume it was because we restored normal PF joint alignment when in fact the improvement had nothing to do with joint alignment.

Based on the results of the preliminary investigation, a broader study including more subjects and testers at several clinical facilities was deemed necessary to examine reliability. The purpose of this study was to determine the intertester reliability of measurements taken with four tests for PF alignment, as described by McConnell.[4] We chose to design the study in a similar fashion to other investigators assessing reliability of clinical assessments.[8]

Method

Subjects

Sixty-six subjects (31 male, 35 female) participated in the study. Subject ages ranged from 14 to 74 years ($\bar{X}$[±SD]=29.7±13.1). Mean height and weight were 171.2±10.2 cm (67.4±4.0 in) and 73.4±19.6 kg (161.9±43.1 lb), respectively. All subjects were referred for physical therapy by their physicians. Subjects were included in the study if the examining therapist believed that assessment of PF alignment would be part of the typical physical therapy evaluation for that patient. Forty subjects had diagnoses directly related to PF dysfunction (ie, PF pain syndrome, anterior knee pain, chondromalacia patellae, subluxating patella, patellar tendinitis, patellar fracture). The remaining subjects had diagnoses consisting of meniscal pathology, ligamentous pathology, and fractures of the femur or tibia. Subjects were excluded from the study if they had received a surgical procedure specifically to realign the patella (eg, lateral retinacular release). All subjects signed an informed consent form prior to participation in the study.

Testers

Testers in this study were 12 physical therapists employed at one of four physical therapy clinics in the Philadelphia, Pa, area. All testers frequently treated patients with knee disorders or PF joint dysfunction in their practice. All testers used PF taping techniques for treating these patients and were familiar with the PF alignment tests prior to participation in the study. Only 1 tester learned the alignment tests from attending a continuing education course given by McConnell. All other testers learned the alignment tests by reading published descriptions of the tests[4] or from colleagues who learned the tests in other continuing education courses. Table 1 provides demographic information of therapists at each clinic site.

Patellofemoral Alignment Tests

Because the testers participating in the study learned the PF alignment tests from varying sources, we decided to provide standardized instructions of these tests. All testers received a written description and a photograph of each specific test of alignment. We chose this method of standardizing the instructions because it would allow our results to be generalized to therapists who followed our written instructions and photographs of the tests. We elected not to perform personal instruction or demonstrations of the tests, because then the results would only be generalizable to therapists who received our personal instruction. The following instructions for the

Figure 1. *Patellofemoral alignment test for medial/lateral displacement. Markings on the patient's skin in the photograph were for illustrative purposes and were not used by testers during the study.*

alignment tests are based on descriptions from McConnell.[4] The wording in following descriptions is exactly as they were presented to the testers.

Medial/lateral displacement. Lateral displacement is determined by palpating the medial and lateral femoral epicondyles with the index fingers and simultaneously palpating the midpatella with the thumbs (Fig. 1). Normally, the distance between the index fingers and the thumbs should be approximately the same.[4] If a lateral displacement is present, then the distance from the index finger palpating the lateral epicondyle to the thumbs will be less than the distance from the finger palpating the medial epicondyle to the thumbs.[4] If a medial displacement is present, the distance from the medial epicondyle to the thumbs will be less than the distance from the lateral epicondyle to the thumbs.[4]

Medial/lateral tilt. The degree of medial or lateral patellar tilting is determined by comparing the height of the medial patellar border with that of the lateral patellar border. The examiner places his or her thumb and index finger on the medial and lateral borders of the patella (Fig. 2). Both digits should be of equal height. If the digit palpating the medial border is more anterior than the lateral border, then the patella is tilted laterally.[4] If the digit palpating the lateral border is more anterior than the medial border, then the patella is tilted medially.[4]

mined by palpating the inferior pole of the patella (Fig. 3). If no significant anterior tilt exists, the inferior pole should be easily palpated.[4] An anterior tilt is present if the examiner must place a downward pressure on the superior pole of the patella so that the inferior pole becomes superficial enough to palpate.[4]

Patellar rotation. Patellar rotation is determined by examining the relationship between the longitudinal axis of the patella and the longitudinal axis of the femur (Fig. 4). The longitudinal axis of the patella should normally be in line with the anterior superior iliac spine (ASIS). If the distal end of the longitudinal axis of the patella is angled lateral to the ASIS, then the patella is considered to be rotated laterally.[4] If the distal end of the longitudinal axis of the patella is angled medial to the ASIS, then the patella is considered to be rotated medially.[4]

Experimental Procedure

All therapists serving as testers received the written instructions and photographs of the PF alignment tests approximately 2 weeks prior to data collection. This procedure allowed testers the opportunity to practice the evaluation procedures prior to participation in the study. We provided testers with the opportunity to ask questions regarding interpretations of the written instructions on the day that testing was initiated at each clinic.

Initially, an attempt was made to select a random pair of therapists to test each patient. Random pairing was not maintained, however, due to scheduling conflicts for both testers and patients. One facility had only two therapists participating in the study, so random pairing was not possible.

Paired testers performed the PF alignment tests independently. The therapist assigned to treat the subject at the time of referral to physical therapy was identified as examiner 1. The paired therapist was identified as examiner 2. Examiner 1 performed the tests of PF alignment first, and then

Figure 2. *Patellofemoral alignment test for medial/lateral tilt. Markings on the patient's skin in the photograph were for illustrative purposes and were not used by testers during the study.*

examiner 2 performed the tests within one treatment session of examiner 1. Most often, testing was performed by both testers during the same session.

The testers were instructed not to discuss the evaluation findings on any subjects until the entire study was completed. This instruction was given

Figure 3. *Patellofemoral alignment test for anterior tilt. Markings on the patient's skin in the photograph were for illustrative purposes and were not used by testers during the study.*

to prevent a tester from obtaining test results or information about the examination process from the other testers.

One individual from each participating facility was designated as the data-collection coordinator. This person collected examination result forms from the examiners, placed the forms in an envelope, and returned these forms to us. This procedure was done in an attempt to maintain confidentiality of the examination results.

Data Analysis

Intertester reliability was determined by calculating kappa coefficients, which are appropriate for nominal-level data.[9] The kappa coefficient is based on the percentage of agreement between repeated assessments that has been corrected for chance agreement.

Results

There were a total of 66 paired assessments for each test of PF alignment. The percentages of agreement and kappa coefficients are reported in Table 2. The percentages of agreement ranged from 44% to 71%. The kappa coefficients ranged from .10 to .36.

Discussion

The low kappa coefficients suggest the reliability of measurements of PF alignment ranged from poor (.00–.10) to fair (.20–.40), according to criteria proposed by Landis and Koch.[10] The kappa coefficients were consistently lower than the percentage-of-agreement values because kappa coefficients represent the proportion of agreement after chance agreement is removed.

The kappa coefficient may be artificially lowered or elevated if there is insufficient variability in the phenomena being assessed.[11] This artificially lowered or elevated value may result in either an underestimation or overestimation of reliabilty. For example, in the evaluation of medial/lateral displacement, there are three possible

Figure 4. *Patellofemoral alignment test for medial/lateral rotation. Markings on the patient's skin in the photograph were for illustrative purposes and were not used by testers during the study.*

choices: medial displacement, lateral displacement, or no displacement. If the sample consisted of subjects who were equally distributed among each of the three possible test results, then the sample would demonstrate reasonable variability in the phenomena being studied and the kappa coefficient would be appropriate. However, if almost all subjects in the sample exhibited a lateral displacement, then the sample would lack adequate variability. A lack of variability would result in a high degree of agreement being attributed to chance and, therefore, a low kappa coefficient.

Table 2. *Kappa Statistic (Percentage of Agreement in Parentheses) for Patellofemoral Alignment Evaluation Procedures*

Procedure	Kappa (Percentage of Agreement)
Medial/lateral displacement	.10 (44%)
Medial/lateral tilt	.21 (59%)
Anterior/posterior tilt	.24 (71%)
Medial/lateral rotation	.36 (61%)

According to Feinstein and Cicchetti,[11] there is no "gold standard" by which adequate variability of scores is determined when using kappa. They suggest that analysis of the marginal totals of scores can indicate whether kappa will be artificially elevated or lowered. If the marginal totals are imbalanced in their distribution, then kappa will be altered. If marginal totals are symmetrically imbalanced, then kappa will be lowered and will tend to underestimate reliability. If marginal totals are asymmetrically imbalanced, kappa will be elevated and will tend to overestimate reliability. The effect of marginal total imbalances on the kappa statistic is probably most serious in cases in which a high percentage of agreement exists.

The distributions of judgments for each test of PF alignment are shown in Tables 3 through 6. The marginal totals (in italics) indicate that there is a symmetrical imbalance (vertical totals increase from top to bottom, horizontal totals increase from left to right) for each table[11]; thus, our kappa values may be artificially lowered. We do not, however, consider the percentage of agreement to be high for any of the tests, and therefore kappa would probably not be seriously affected. Hence, we believe our kappa values reflect the degree of reliability of the PF alignment measurements, and they are poor to fair at best.

Table 3. *Distribution of Paired Judgments for Medial/Lateral Displacement*

	Displacement			
	Medial	None	Lateral	Total
Medial	5	3	3	*11*
None	4	10	10	*24*
Lateral	3	9	19	*31*
Total	*12*	*22*	*32*	

Table 4. *Distribution of Paired Judgments for Medial/Lateral Tilting*

	Tilting			
	Medial	None	Lateral	Total
Medial	0	0	1	*1*
None	3	11	11	*25*
Lateral	3	9	28	*40*
Total	*6*	*20*	*40*	

Table 5. *Distribution of Paired Judgments for Medial/Lateral Rotation*

	Rotation			
	Medial	None	Lateral	Total
Medial	2	1	6	*9*
None	3	17	5	*25*
Lateral	4	7	21	*32*
Total	*9*	*25*	*32*	

Table 6. *Distribution of Paired Judgments for Anterior Tilting*

	Tilting		
	Anterior	None	Total
Anterior	7	8	15
None	11	40	51
Total	18	48	

Several factors may have contributed to the poor reliability of the PF alignment measurements in this study. Perhaps the most influential factor is that testers were required to palpate bony landmarks that may be difficult to palpate accurately. The examination procedure for medial/lateral displacement serves as an example. This procedure involves palpation of the medial and lateral femoral epicondyles and the center of the patella. The medial and lateral femoral epicondyles are not discrete prominences, and they vary in size and shape across individuals. It is possible that two examiners could correctly palpate one of these structures but their finger placements may be several millimeters apart. Likewise, the shape, size, and orientation of the patella varies across individuals, making it difficult to accurately palpate the center of the patella.

Errors in visual inspection of the patellar position with respect to the femur may have contributed to the poor reliability of the measurements. Because the bony segments of the PF joint are relatively small, errors due to visual estimation may have been magnified.

All examiners were given the same written instructions and photographs of the evaluation procedures. We believed that this was an acceptable way of standardizing the testing procedures, because many therapists learn evaluation and treatment techniques through descriptions of the techniques in the literature. It may be possible that these instructions were interpreted differently across therapists. We attempted to minimize problems with interpretation of the instructions by providing a question-and-answer period on the day that testing was initiated at each clinic. This precaution would not, however, completely eliminate the potential for varying interpretations of the instructions. The written instructions given to the examiners were based on the descriptions of the procedures provided by McConnell.[4] Modifications to these instructions may improve the reliability of the evaluation procedure. We believe, however, that an evaluation that is based on palpation of nondiscrete bony landmarks and visual inspection of relatively small bony segments is inherently unreliable.

Another potential source of error was that examiner 1 always had knowledge of the physician's diagnosis for the patient because examiner 1 was the treating therapist. Unfortunately, we are not certain whether examiner 2 always had this information. Therefore, examiner 1 may have been biased by knowing the physician's diagnosis prior to performing the PF alignment tests.

Clinical Implications

The PF alignment tests in this study were initially developed, in part, to guide clinical decisions regarding PF taping procedures. Because these PF alignment tests do not exhibit a high degree of reliability, they may not provide valid information that would guide clinical decisions for PF taping or therapeutic exercise. This concern does not, however, discount the usefulness of PF taping techniques. In our clinical experience, the PF taping procedures described by McConnell[4] can be effective in reducing symptoms.

Physical therapists may choose to use other methods of determining when and how to apply PF taping techniques. Some clinicians in our area use the patellar tilt test and patellar glide test described by Kolowich et al[12] to guide clinical decisions regarding taping. The reliability of measurements obtained with these tests, however, is also unknown.

Because we have been unable to find a reliable clinical method of assessing PF alignment, we recommend selecting taping techniques based on the immediate response of the patient's symptoms to a specific taping technique. This method is not dependent on any judgment of PF alignment. The critical first step in this method is to identify a painful activity, such as stair climbing, squatting, or manually resisted knee extension. This activity serves as the basis for judging the effect of the tape on the patient's symptoms. We then systematically apply specific taping techniques until the patient's symptoms are significantly reduced or completely alleviated.

Conclusions

Four clinical tests of PF alignment were found to lack reliability in this study. Without reliability, these tests would not be useful in guiding treatment decisions for PF taping or therapeutic exercise. Therapists are encouraged to seek other methods to guide clinical decision making for these treatments.

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Invited Commentary

Fitzgerald and McClure are to be commended for their study on "the reliability of four tests for patellofemoral alignment." With the push to demonstrate the efficacy of physical therapy, there is a need to critically analyze the reliability of measurements obtained with the assessment procedures we use. This study should teach us to be cautious about making dogmatic statements on the basis of one assessment procedure, particularly when it can be shown that different therapists can produce different results using the "same" procedure. We should realize that in many instances these tests should guide, not dictate, our treatment and that it is the patient's response to the treatment that will direct and fine-tune our treatment further.

The study by Fitzgerald and McClure confirms the findings of Artemieff et al on asymptomatic individuals[1] and of Norman et al on symptomatic individuals.[2] The unpublished study by Artemieff et al revealed that the reliability of assessing patellar position was poor on all four components. Their study, however, was performed only on asymptomatic individuals, so it was thought that the therapists were expecting abnormalities, when such abnormalities perhaps did not exist. Artemieff et al also concluded that the greatest source of error was the identification of the bony landmarks, as no single reference point was easily distinguishable.

The study by Artemieff et al[1] was modified by Norman et al,[2] who examined the reliability of measurements obtained by five therapists assessing the patellar position in 20 symptomatic individuals. In this unpublished study, each subject was assessed by all five therapists at the beginning of the treatment session, so any tissue change during treatment could not influence the assessment. The written instructions for palpation were more specific in an attempt to minimize the problem of bony landmark identification. The results of Norman and colleagues' study demonstrated a high percentage of agreement among the therapists, but, because there was little variability in the data, the expected agreement was also high. Therefore, the Kappa values were lower and in fact worse than the Kappa values reported by Fitzgerald and McClure (κ=.10–.36). Norman et al hypothesized that the lack of reported variability of patellar position may have occurred because the examiners were expecting alterations in patellar position as all subjects were symptomatic. It seems that whenever the reliability of measurements involves manual examination, the outcome is always poor.

Potter and Rothstein[3] found poor reliability in 11 sacroiliac joint tests that required accurate palpation of bony landmarks. It has been found on numerous occasions[4–7] that measurements based on palpations are unreliable for determining stiffness in the spine. However, in the hands of a skilled practitioner, manual examination has been found to reliably detect the pathognomic segment in patients with spinal pain.[8–11] These articles,[8–11] however, emphasize the importance of the skill level of the individual therapist in the particular manual technique. To improve the skill level, it may be necessary for us to examine the way manual techniques are learned. Feedback needs to be precise. Lee et al[12] demonstrated that immediate quantitative feedback, using an oscilloscope during spinal mobilization, increased the accuracy and consistency in producing a given force. It is difficult to imagine how most children could learn to play a musical instrument or a particular sport with only written instruction, no guidance from an instructor, and no time allocated for practice.

There appear to be two inherent assumptions in the studies examining the reliability of measurements obtained by palpation: (1) The palpatory skill level of all physical therapists is the same, and (2) all therapists will immediately acquire, from the written instructions, the same level of expertise. Perhaps, when learning techniques dependent upon palpatory skill, therapists need to feel, as well as be shown, examples of the extremes in the assessment so that they can begin to develop an appreciation of the range of possibilities. The feedback given needs to be precise, and time must be allocated for practice to improve the skill level. In doing so,

we must not lose sight of the fact that we are actually neuromusculoskeletal detectives with several pieces to a puzzle, which we must put together to determine not only the source of the patient's symptoms but also the underlying cause(s) of the problem before formulating a treatment plan. For example, when a patient comes in with patellofemoral pain, we determine the problem and how best to manage it from information gleaned from the history, as well as from different movement and alignment tests. We then implement a treatment. The bottom line is whether the patient improved with our treatment, not whether five therapists performing the same test in isolation, with no knowledge of the patient's problem, come to the same conclusion after testing.

The patient—the consumer of the treatment—is probably not particularly interested in the reliability of measurements obtained with a certain test, but is extremely concerned about symptom relief. To date, there have not been many studies in physical therapy that have actually validated clinical results. We are in a "catch-22" situation because we need outcome studies to demonstrate our worth, but we also need reliable and valid measurements to document these outcomes. In some instances, however, improved objective measurements, such as an increase in spinal flexion, have not always reflected any improvement in functional outcome, such as being able to sit at a desk, without pain, for an increased period of time.

This is a difficult, but exciting, time facing our profession. Let us hope that we can rise to the challenges confronting us and not be overwhelmed by the problems. Perhaps we should concentrate our efforts on developing instruments, such that the measurements taken from these instruments are reliable. After all, some measurements of spinal stiffness and knee joint laxity have become reliable with the introduction of external measuring devices.[13] Is this the only way we can improve our measurement, or should we rethink our methodology when testing the reliability of palpation skills? Perhaps we should be examining whether therapists would have a similar strategy for treatment (in this case, whether therapists would nominate a similar taping method for a particular patient) after they obtained all the information they considered necessary to make that decision. I feel that there are many factors that influence our final decision, and I would be surprised and disappointed if clinicians based all their clinical judgments on a single assessment procedure.

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Author Response

We appreciate this opportunity to further emphasize and perhaps clarify the implications of our study. Although the tests described in our study are popular, their place in clinical practice needs to be reconsidered.

Measurements obtained from clinical tests can serve to either guide treatment or determine treatment outcome, or, in some cases, they can serve both of these purposes. The measurements of patellofemoral (PF) alignment described in our article were originally proposed by McConnell[1] to assist in selecting PF taping techniques for patients with PF dysfunction. Although we have had success with PF taping for our patients, as determined by improved functional ability and the patients' reports of reduced pain, we do not believe measurements of PF alignment have played a meaningful

role in the treatment selection process. One major factor supporting this belief is that the PF alignment tests demonstrate poor measurement reliability. In our study, not only did the examiners fail to agree on the same alignment characteristic, in some cases the examiners obtained results that would have resulted in exact opposite treatment recommendations (eg, taping for medial displacement as opposed to lateral displacement). Given these findings, it is difficult to accept that these measurements would provide any meaningful data for the purpose of guiding treatment selection.

Another factor to consider is the relationship between PF alignment and PF pain. Although it seems to be generally accepted that PF alignment is related to PF pain, experimental evidence does not support this notion. Bockrath et al[2] examined the effect of PF taping on PF pain and PF alignment, as determined by radiological ... tion in PF pain after treatment, with no evidence of change in PF alignment. According to Hughston et al,[3] the Q angle, another measure of PF alignment, is not always related to complaints of PF pain. If the construct being measured is not related to the clinical problem, then it is doubtful that the measurements will provide meaningful data that assist in guiding treatment decisions, regardless of measurement reliability or examiner experience.

We agree with Ms McConnell that clinical decision making and treatment planning require the integration of meaningful data acquired from several aspects of the patient history and clinical examination. Because we do not believe the measurements of PF alignment described in our report provide meaningful data for guiding PF taping treatment selection, we no longer include them in our evaluation. functional outcome in response to taping, as Ms McConnell also suggests, will probably yield the most meaningful information for guiding treatment decisions. Given that there are a limited number of taping techniques to select, we recommend starting with one technique and then modifying the technique as necessary according to patient response.

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Applicants Sought To Develop the National PT and PTA Licensure Examinations

The Federation of State Boards of Physical Therapy (FSBPT) is seeking applicants for three committees that develop the national PT and PTA licensure examinations: the Item Writer and Review Committee (IWRC, formerly ACE), the Item Bank Review Committee (IBRC), and the Examination Construction and Review Committee (ECRC, formerly CLE).

For a description of committee responsibilities and schedule and an application form, please contact Joanne Crump at 703/553-2591 or 703/553-7163 (FAX). A curriculum vitae or résumé **must** be submitted with each application.

The deadline for completed applications and résumés is April 7, 1995.