Interrater Reliability of the Prone Apprehension Relocation Test

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Background: The Prone Apprehension Relocation Test (PART) augments existing radiographic measures and clinical provocative maneuvers in diagnosing hip instability. One measure of the potential clinical utility of the PART depends on the reproducibility of test results by evaluating providers including physicians, licensed athletic trainers, and physical therapists.

Purpose: To determine the interrater reliability of the PART among health care providers.

Study Design: Cohort study (diagnosis); Level of evidence, 3.

Methods: We retrospectively identified patients in our institution's hip preservation registry who presented between September 2017 and June 2019 for evaluation of hip pain. Patients included in the study had the PART performed by a single physician as well as 1 of 12 physician extenders (a licensed athletic trainer or a physical therapist). The providers were blinded to the findings of the other examining professional. Interrater reliability was assessed using the Cohen κ ($\geq$0.75 was considered excellent; between 0.75 and 0.40, moderate; and $\leq$0.40, poor).

Results: A total of 96 patients (190 hips) were included in this study (61 women and 35 men, average age 32 $\pm$ 12.1 years). A total of 23 hips had a positive PART from both examiners. Interrater reliability was excellent between health care professionals for the PART when evaluating the right hip ($\kappa = 0.80$), left hip ($\kappa = 0.82$), and when combining the results for left and right ($\kappa = 0.81$). A subanalysis of patients with a positive PART from both raters demonstrated that 19 of the 23 hips had a lateral center-edge angle $>25^\circ$.

Conclusion: Our study demonstrated excellent interrater reliability of the PART, supporting its use in the physical evaluation of painful hips.

Keywords: hip/pelvis/thigh; hip dysplasia/instability; Prone Apprehension Relocation Test (PART); reliability

Hip dysplasia and related hip instability can cause pain, limit hip function, and ultimately lead to early osteoarthritis. In addition to acetabular undercoverage, additional factors that can contribute to hip instability include femoroacetabular impingement (FAI)-induced instability[4] and soft tissue laxity.[12] Hip dysplasia is often diagnosed with an anterior-posterior (AP) pelvic radiograph. The literature has supported a normal lateral center-edge angle (LCEA) as $\geq 25^\circ$, borderline dysplasia with an LCEA of 18° to 25°, and true dysplasia with an LCEA $<18^\circ$,[5,13] although some clinicians diagnose borderline dysplasia with an LCEA of 20° to 25° and true dysplasia with an LCEA $<20^\circ$[11] (Figure 1).

In addition to the LCEA, there are several radiographic measurements that have been described to diagnose hip dysplasia and acetabular morphologic abnormalities, including AP wall indices,[1,23] crossover and posterior wall signs,[19] acetabular index,[20] acetabular depth-to-width ratio,[6] femoroepiphyseal acetabular roof index,[26] and cliff sign.[17] Some patients, however, with insufficient coverage of the femoral head do not meet the radiographic definition of dysplasia.[24] In fact, hip instability has been described in the setting of normal acetabular coverage.[14] It is due to this significant

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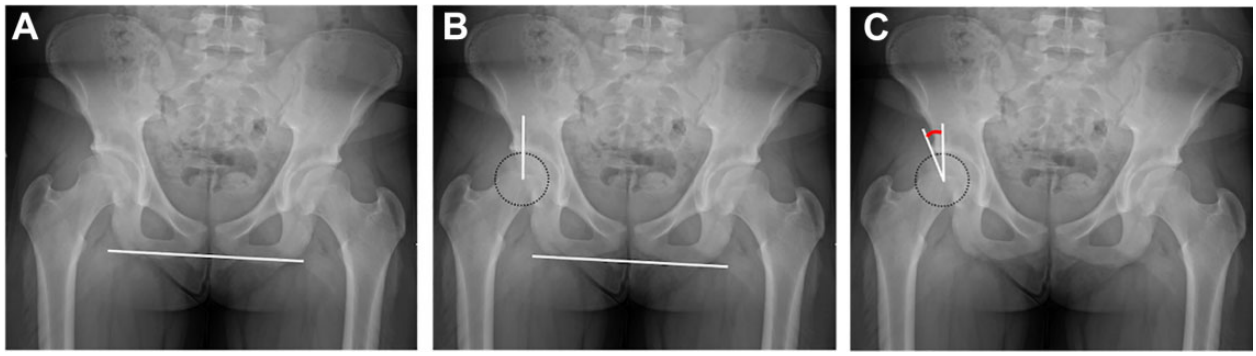

Figure 1. The lateral center-edge angle (LCEA; red in image C) is measured by (A) first drawing a line from the bottom of one ischium to the other, then (B) drawing a line that is 90° perpendicular to this line and ending at the center of the femoral head, and finally by (C) measuring the angle from the line drawn in (B) to a line drawn from the center of the femoral head to the most lateral aspect of the acetabular sourcil.

variability in diagnostic criteria, as well as the presence of the diagnosis in the absence of radiographic findings, that provocative physical examination maneuvers are a necessary addition to the nuanced diagnosis of hip dysplasia.

One recently described maneuver, the Prone Apprehension Relocation Test (PART), augments traditional clinical examination to identify patients with symptomatic hip undercoverage.[24] For the PART, the patient lies prone with the affected hip held in extension while the examiner pushes downward on the femur and supports the knee (see Video Supplement for a demonstration). A positive PART replicates the patient's anterior hip pain, and this anterior hip pain dissipates when the examiner removes downward pressure on the femur. The PART is positive in patients with significantly increased acetabular anteversion at the 3-o'clock position as demonstrated on a computed tomography (CT) scan, which is often not visible on AP pelvis radiographs[24] (Figure 2). The PART is a valuable addition to clinical examination for patients with hip instability, particularly those with borderline or "occult" dysplasia.[24]

One measure of the potential clinical utility of the PART is the reproducibility of this test among evaluating providers. The purpose of this study was to quantify the interrater reliability of the PART among health care professionals.

METHODS

This retrospective cross-sectional study was determined to be exempt by our institutional review board. We assessed the interrater reliability between the senior author (A.M.S.), who is a hip-preservation orthopaedic surgeon, and 12 other health care professionals acting as physician extenders, including 10 licensed athletic trainers and 2 physical therapists (hereafter known collectively as "physician extenders" or "extenders") who had been trained by the senior author on how to perform the PART maneuver. In the clinic, the extender examined the patient first and recorded his/her PART finding. The senior author, at a later time during the clinic visit and blinded to the extender's examination findings, assessed the patient and independently recorded her assessment. We also assessed the radiographic characteristics of patients with a positive PART from both raters. Data were analyzed using SPSS Version 23 (IBM).

Participants

We retrospectively identified patients in our institution's prospectively collected hip-preservation registry who presented between September 2017 and June 2019 for evaluation of hip pain. Inclusion criteria were new patients presenting to the clinic with hip pain who had the PART maneuver performed by both the senior author (A.M.S.) and another health care professional acting as a physician extender, which was standard of care for all new hip patients. This patient population included patients suspected of having hip dysplasia and FAI as well as various other hip pathologies. Exclusion criteria were patients having previously undergone total hip arthroplasty as well as those who did not have the maneuver performed by both examiners.

PART Procedure

A standardized protocol for performing PART was incorporated into the routine assessment of new patients presenting with hip pain (Figure 3 and Video Supplement).[24] Participants were instructed to lie prone on the examination table with the affected hip held in approximately 10° to 15° of extension and approximately 10° of abduction from neutral (Figure 3A). The examiner supported the patient's bent knee and pushed downward (anteriorly) on the femur while supporting the knee (Figure 3B) and subsequently released the downward pressure (Figure 3C). A positive PART replicated the patient's anterior hip pain with downward pressure, which was relieved when the pressure was removed.[24] This was repeated on the patient's contralateral hip. This standardized PART examination was performed by each of the examiners on the same patient visit, and each examiner was blinded to the other's results. The senior author performed the PART on all patients included in this

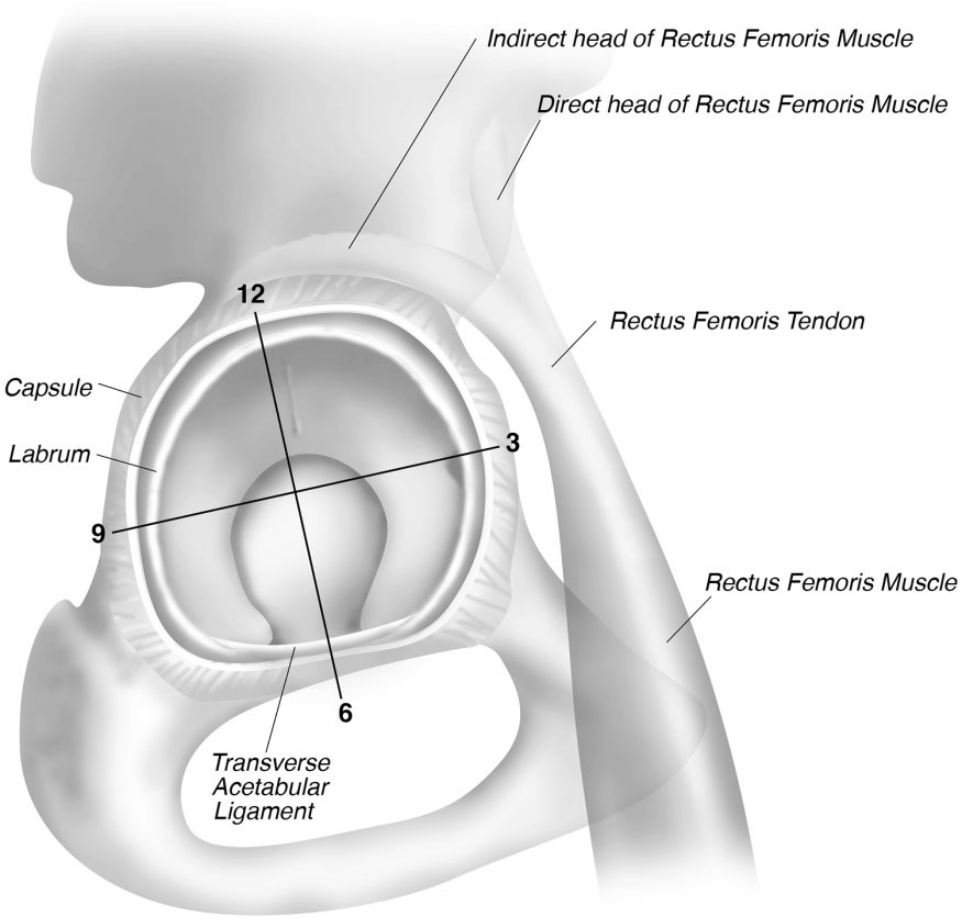

Figure 2. Diagram of acetabulum as clockface. Acetabular version is typically reported at the 1-, 2-, and 3-o'clock positions based on computed tomography measurements. Patients with a positive PART have significantly more acetabular anteversion at the 3-o'clock position than those with a negative PART.[24] PART, Prone Apprehension Relocation Test.

Figure 3. The PART maneuver. (A) The patient lies prone on the examination table with the affected hip held in approximately 10° to 15° of extension and approximately 10° of abduction from midline. The examiner supports the patient's bent knee. (B) The examiner pushes downward on the femur while supporting the knee. A positive test replicates the patient's anterior hip pain. (C) The examiner releases downward pressure on the femur, and this relieves the patient's anterior hip pain. PART, Prone Apprehension Relocation Test. (Image reproduced from Spiker et al[24] with permission from Oxford University Press.)

TABLE 1
Characteristics of Study Participants[a]

Variable	Value
Sex	
Male	35 (36%)
Female	61 (64%)
Body mass index, kg/m^2	26.2 ± 6.2
Age, y	32 ± 12.1
Affected hip	
Right	49 (51%)
Left	39 (41%)
Bilateral	8 (8%)

[a]Data are reported as number of patients (%). E1, examiner 1 (either a licensed athletic trainer or physical therapist); E2, examiner 2 (hip preservation orthopaedic surgeon).

study and was always the second examiner to perform the PART.

Reliability

Interrater reliability using the Cohen κ assessed dichotomous results of a positive PART versus a negative PART, whereby κ ≥0.75 was considered excellent; between 0.75 and 0.40, moderate; and ≤0.40, poor.[2,15]

RESULTS

A total of 96 patients (190 hips) were included in this study (61 women and 35 men; average age, 32 ± 12.1 years; average body mass index [BMI], 26.2 ± 6.2 kg/m^2) (Table 1). Of the total, 23 hips had a positive PART for both examiners, 158 hips had a negative PART for both examiners, and 9 hips had discordant results between examiners, with the extenders overcalling a positive PART 1.6% of the time relative to the surgeon. However, with the small number of discordant results, this was not statistically significant. The κ values for interrater reliability are presented in Table 2. The κ of 0.80 for right hips, 0.82 for left hips, and 0.81 for both sides of the hips all demonstrated excellent reliability. A subanalysis of the 23 hips that had a positive PART from both raters demonstrated that 19 of the 23 hips (82.6%) had an LCEA of >25°.

DISCUSSION

Although hip dysplasia is classically characterized by an LCEA of <25°on standard AP pelvis radiographs,[5,13] there are patients who may not fit this criterion but who have occult dysplasia (focal undercoverage anteriorly or posteriorly) and/or clinical hip instability.[14,25] The distinction between the radiographic diagnosis of dysplasia and the clinical diagnosis of instability is often blurred or overlapping, which supports the need for diagnostic tools in making these diagnoses. Multiple examination maneuvers have been described to diagnose hip dysplasia and instability,

TABLE 2
κ Values for Interrater Reliability Between Health Care Professionals[a]

A. Right Hip

	E2: Negative	E2: Positive	κ (95% CI): 0.80 (0.63-0.97) P < .001
E1: Negative	77 (81.9%)	4 (4.3%)	
E1: Positive	1 (1.1%)	12 (12.8%)	

B. Left Hip

	E2: Negative	E2: Positive	κ (95% CI): 0.82 (0.64-0.99) P < .001
E1: Negative	81 (84.4%)	2 (2.1%)	
E1: Positive	2 (2.1%)	11 (11.5%)	

C. Left and Right Hips Together

	E2: Negative	E2: Positive	κ (95% CI): 0.81 (0.69-0.93) P < .001
E1: Negative	158 (83.2%)	6 (3.2%)	
E1: Positive	3 (1.6%)	23 (12.1%)	

[a]Data are reported as number of patients (%). E1, examiner 1 (either a licensed athletic trainer or physical therapist); E2, examiner 2 (hip preservation orthopaedic surgeon).

but currently, there is no single examination that serves as the gold standard.[24] The PART is a recently described provocative examination maneuver that may supplement other provocative tests and radiographic findings of dysplasia. Spiker et al[24] demonstrated that patients with a positive PART had significantly higher acetabular version at the 3-o'clock position as identified on CT. The interobserver reliability of this maneuver has not previously been assessed in the literature. This study demonstrates that there is excellent interrater reliability of the PART when performed by different health care professionals.

Other physical examination maneuvers that identify hip instability include the abduction-hyper-extension-external rotation test (AB-HEER),[7] anterior apprehension test (also known as the hyper-extension-external-rotation test, HEER),[22] axial distraction test,[21] log roll test,[22] posterior apprehension test,[22] and the prone external rotation test.[18] Each of these exams assesses the hip in different dynamic positions (Table 3); however, the PART is one of the first examination maneuvers for which a positive finding has been associated with an anatomic variation (specifically increased acetabular version at the 3-o'clock position).[24]

Hoppe et al[8] tested the diagnostic accuracy but not interrater reliability of several tests, including the AB-HEER, the prone instability test, and the HEER, and found that of the 3, the AB-HEER test was the most accurate.[8] Safran[21] summarized test accuracy but not interrater reliability and found that the anterior apprehension test is 71% sensitive and 85% specific; the AB-HEER is 81% sensitive and 89%

TABLE 3
Summary of Tests to Evaluate Hip Instability[a]

Summary of Tests to Evaluate Hip Instability	Patient Position	Description of How to Perform Examination
Abduction-extension-external rotation test[7]	Lateral	• Hip is abducted to 30° and externally rotated. Pressure is placed on posterior aspect of greater trochanter. Leg is extended from 10° of flexion to full extension while anterior force is applied through greater trochanter. • Positive test reproduces the patient's symptoms.
Anterior apprehension test (also known as hyper-extension-external rotation test)[22]	Supine	• Buttock of side being examined is at edge of table. Affected lower extremity extended and externally rotated with contralateral limb in flexion. • Positive test reproduces anterior hip pain.
Axial distraction test[21]	Supine	• Patient's hip and knee are flexed at 30°. Examiner's knee beneath affected thigh, against ischium. • Axial distraction of hip results in positive test if patient's pain or apprehension is replicated, or whether hip toggles.
Log roll test (also known as the dial test)[22]	Supine	• Examiner internally rotates foot past neutral and releases foot. • Foot will fall into external rotation (ER); if ER is greater than contralateral side, this is suggestive of anterior capsular laxity (especially if foot table angle is <20°) and is a positive test.
Posterior apprehension test[22]	Supine	• Affected hip in 90° of flexion. Additional adduction and internal rotation of affected hip. • Posterior force is applied. Test is positive if pain or apprehension is reproduced.
Prone Apprehension Relocation Test[24]	Prone	• The patient lies prone on the examination table with the affected hip held in extension approximately 10° to 15° and abducted approximately 10° from midline. The examiner supports the patient's bent knee. The examiner pushes downward on the femur while supporting the knee. • A positive test replicates the patient's anterior hip pain.
Prone external rotation test[18]	Prone	• Affected hip is maximally externally rotated. Anterior pressure is placed on the posterior greater trochanter to translate the femoral head anteriorly. • Positive test replicates patient's symptoms.

[a]Modified from Spiker et al.[24]

specific; and the prone external rotation test is 33% sensitive and 98% specific.[21] The current study looks at the interrater reliability of the PART maneuver using the κ statistic, which is a common metric for interrater reliability.[3,9,16] The high κ scores for the current study demonstrate that the PART is reproducible among health care professionals.

A subanalysis of the 23 hips that had a positive PART from both raters demonstrated that 19 of the 23 hips (82.6%) had an LCEA of >25°. Thus, by AP pelvic radiographic imaging alone, these patients would not have been classified as dysplastic. Although the present study was not designed to test the sensitivity or specificity of the PART, it is consistent with a previously published work that highlights the limitations of the LCEA as a measure of hip instability.[10,24] Previous analysis found no statistically significant difference in LCEA between patients with a positive PART and those with a negative PART.[24]

This study has several limitations. First, each of the physician extenders who performed the PART were trained by the senior author who afforded direct feedback during the learning curve for the PART. The health care providers who acted as physician extenders who

performed the PART other than the senior author were licensed athletic trainers or physical therapists. There were 12 total physician extenders, and while we confirmed that discordant results were all not associated with the same extender, we were underpowered to perform a subanalysis of the athletic trainers compared with the physical therapists. Further study may help substantiate that this test is generalizable to other providers, such as residents, fellows, nurse practitioners, and physician assistants. Moreover, further study may also elucidate whether a patient's response to the PART maneuver is consistent over time. To study interrater reliability, we chose to include patients who were evaluated on the same day by 2 practitioners. The consistency of a positive test over time and after treatment, however, will help define its role in clinical practice. Another limitation is that our study is narrowly focused on interrater reliability and does not include analysis of CT measurements, which was the focus of a prior study,[24] and should be viewed in this context. Finally, this study's retrospective design and potential patient selection bias is a limitation. Inclusion criteria included all patients with hip pain who presented to our clinic and thus included a wide spectrum of hip pathology, including FAI and hip dysplasia, as well as mild-to-moderate hip osteoarthritis, extra-articular impingement, and other hip pathology. While we acknowledge the limitations of our study, we hope that our results demonstrating high interrater reliability in the setting of these limitations will serve as a starting point for further, larger validation investigations.

CONCLUSION

In the current study, we demonstrated excellent interrater reliability among health care professionals who perform the PART. Given the reproducibility of the PART, which is positive in patients with increased acetabular anteversion at the 3-o'clock position, this examination may offer the clinician an additional tool in the diagnosis of focal acetabular undercoverage that does not meet the classic LCEA $<25^{\circ}$ criteria and/or clinical hip instability in those patients presenting with hip pain.

A Video Supplement for this article is available at http://journals.sagepub.com/doi/suppl/10.1177/23259671211032229

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