

# The Porcellini test: a novel test for accurate diagnosis of posterior labral tears of the shoulder: comparative analysis with the established tests

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## Abstract

**Questions/purposes** Although the posterior labral tears of the shoulder are known for their disabling clinical course, especially in overhead athletes, no clinical test used in isolation can diagnose it accurately in the preoperative period. We wanted to: (1) introduce “Porcellini test” with its radiological verification furnishing the anatomical basis of its mechanism; (2) determine its accuracy; and (3) compare its accuracy with that of the other established tests for diagnosing posterior labral tears of the shoulder.

**Methods** To determine the anatomical basis, we initially performed radiological verification of our test. Then, we evaluated its accuracy in a retrospective case-controlled study on 310 consecutive patients who underwent shoulder arthroscopic procedures at our hospital between January 2013 and December 2013. All patients were examined preoperatively for Porcellini test, and the presence of posterior labral tear was confirmed on arthroscopy. Later, in a cohort study on 91 consecutive patients who underwent shoulder arthroscopic procedures, we compared its accuracy with O’Brien’s test, the Kim test, the Jerk test,

and the Load and Shift test. The accuracy was interpreted in terms of sensitivity, specificity, and predictive values.

**Results** The radiological verification conferred the anatomical basis for the mechanism of the Porcellini test. This new test showed high accuracy for posterior labral tears with sensitivity of 100 %, specificity of 99.3 %, the positive and negative predictive values of 92.6 and 100 %, respectively. Also, it had superior accuracy results than every other test. The interexaminer reliability for all test results was found to be >0.80.

**Conclusions** We propose “Porcellini test” as a simple, accurate, reproducible, and reliable test for the preoperative diagnosis of posterior labral tears of shoulder.

**Keywords** Posterior labral tear shoulder · Diagnostic tests · Test accuracy

## Introduction

Posterior labral injury is relatively uncommon but disabling condition taking its toll mainly in the athletic population engaged in repetitive overhead activities [1–3]. These lesions can present either in isolation or in a conjunction with other pathologies like rotator cuff tears, instability or biceps tendon pathologies [4]. Successful return to the pre-injury level with unrestricted function needs integrated approach consisting of precise diagnosis, surgical or non-surgical management, and rehabilitation. As accurate diagnosis can be a key toward successful management, having an accurate diagnostic tool in the armamentarium of the shoulder surgeon is of paramount importance.

However, the diagnosis and treatment of labral pathologies of the shoulder remain the subjects of

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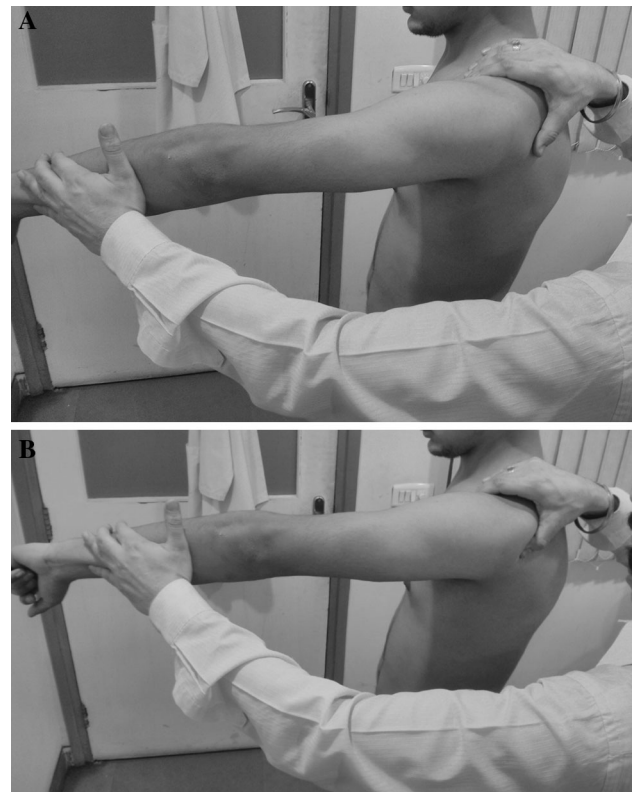
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significant controversy [5]. Several clinical tests have been described in the literature for the diagnosis of posterior labral tears with varying degrees of sensitivity and specificity, which include the O'Brien's test [6], the Kim test [7], the Jerk test [6], and the Load and Shift test [8]. However, most of them are either cumbersome to perform in an anxious and apprehensive patient or do not effectively distinguish posterior labral tears from other shoulder pathologies. Unfortunately, when used individually, these tests may have a low specificity. Furthermore, the accuracy of MRI for detection of a posterior labral lesion has been shown to be lower than that for detection of an anteroinferior labral lesion [9, 10]. Thus, the lack of a reliable and accurate diagnostic tool for this entity has made its diagnosis challenging. The inadequate diagnosis, in turn, might have led to its seemingly lower incidence of approximately 5 %, as reported previously [11]. Because of these issues, its clinical course and management appear to be poorly understood and it is not surprising that the literature is scant of studies elaborating the precise diagnosis in this small subset of patients.

Hence, we endeavored to develop a clinical test for posterior labral tears that would be simple to perform and would have high accuracy and reproducibility. The purposes of this study were to introduce a novel test, "Porcellini test," with its radiological verification furnishing a substantial anatomical basis of its mechanism, to determine its accuracy, and to compare the same with the established standard tests. We hypothesized that this novel test would have high accuracy and reproducibility in diagnosing posterior labral tears. We also hypothesized that it would be more accurate in terms of sensitivity and specificity compared to other existing tests.

## Materials and methods

The Porcellini test can be performed in either sitting or standing position. It comprises of two maneuvers. First maneuver (Fig. 1a) is similar to the O'Brien's test, in which, with the examiner standing behind the patient, the patient is asked to forward flex the affected arm 90° with the elbow in full extension. The patient then adducts the arm 10°–15° medial to the sagittal plane of the body and then internally rotates so that the thumb points downward. After stabilizing the scapula with one hand, the patient is asked to actively elevate the arm against the resistance offered by the examiner's other hand at the forearm or elbow and the strength and perception of pain by the patient are noted. In the second maneuver (Fig. 1b), maintaining the same patient's position, the thumb of the scapular stabilizing hand is placed just lateral to the posterior joint line maintaining a moderate anterior force in



**Fig. 1** "Porcellini" test. **a** With the examiner standing behind the patient, the patient's arm is forward flexed to 90°, adducted 10°–15°, and maximally internally rotated. After stabilizing the scapula with one hand, the patient was asked to elevate the arm against the resistance and the pain and strength were noted. **b** The thumb of the examiner's hand was placed just lateral to the posterior joint line maintaining a moderate anterior force in order to prevent the humeral head from subluxating posteriorly, and then the maneuver was repeated. The test was considered positive if the pain with or without weakness noticed during the first maneuver was reduced or eliminated during the second maneuver

order to prevent the humeral head from subluxating posteriorly. Again the patient is asked to actively elevate the arm against resistance, and the change in the strength and pain perception is noted. The test is considered positive if the pain with or without weakness noticed during the first maneuver is reduced or eliminated during the second maneuver. To determine the anatomical basis for this test, we initially performed radiological verification and then the entire study was conducted in two parts. In the former part, we determined its accuracy; and in latter part, we compared its effectiveness with other established tests. This study was approved by the Institutional Review Board of our hospital, and all patients provided informed consent for undergoing the diagnostic tests and for the use of medical records.

The test was evaluated radiographically in two subjects with suspected posterior labral tear and in one healthy volunteer serving as a control. Both the patients were

young male adults whose participation in sports (cricket and judo, respectively) was affected by shoulder pain and weakness. The Porcellini test was positive in both the patients and negative in the control. Informed consent was obtained from all of the three for the radiographic examination. The axillary view of the shoulder was taken during the two maneuvers (Fig. 2a, b) using portable C-arm fluoroscopic system (SIREMOBIL Compact L, Siemens Medical Solutions USA Inc., Malvern, PA, USA). The images were exported as JPEGs with a 1024 × 1024 resolution. The spherical articular part of the humeral head and the superior and inferior glenoid edges were hand-digitized using ImageJ software [12]. The center of the humeral head was estimated using a least squares algorithm. The glenoid axis was formed by connecting the anterior and posterior glenoid edges, and its center was identified. The perpendicular distance between the center of humeral head and a line perpendicular to glenoid axis passing through the center of the glenoid was calculated. It was corrected for magnification errors using dimensions of known object in field. Then the difference in the amount of translation during both maneuvers was normalized to the humeral head radius. In both the patients, the humeral head translated considerably in the posterior direction during first maneuver (Table 1). Also, they experienced pain and could not provide much resistance against the downward force [manual muscle grade (MMT) grade <4]. However, during the second maneuver, the posterior translation of humeral head was effectively prevented by the examiner's thumb; thus, probably off-loading the torn posterior labrum results in elimination of pain and weakness. The presence of posterior labral tear was then confirmed in both the patients by arthroscopic evaluation. The humeral head of

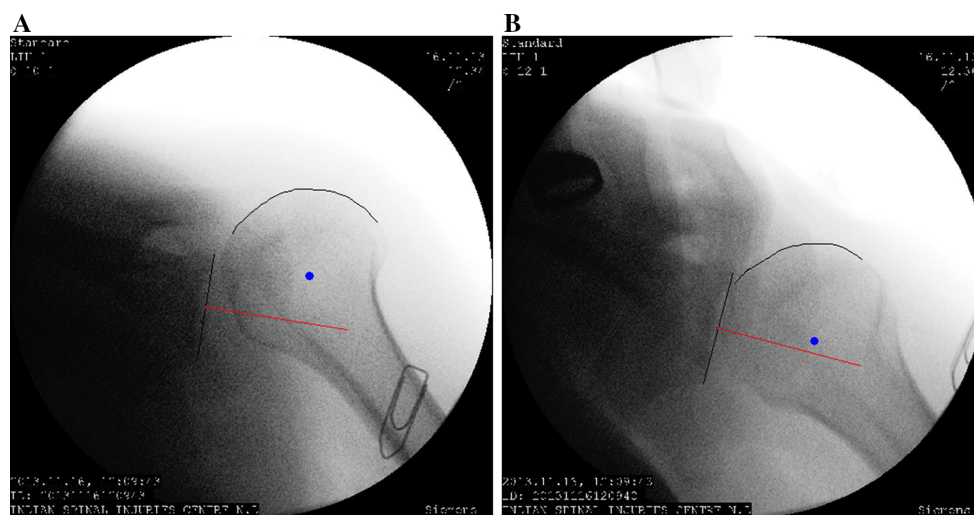
**Table 1** Results of the radiographic verification of the Porcellini test

Parameter	Patient 1	Patient 2	Control
Age (years)	18	21	34
Gender	Male	Male	Female
Translation of humeral head in test position A	10.8 mm	6.7 mm	1.3 mm
Translation of humeral head in test position B	2.9 mm	−2.1 mm <sup>a</sup>	1.1 mm
Difference in translation of humeral head in terms of percentage of humeral head radius	41.3	38.5	<1

<sup>a</sup> Signifies anterior translation

the healthy volunteer did not show significant difference in the amount of posterior translation during both the maneuvers (Table 1).

To determine the accuracy of this test, we conducted a retrospective case-controlled study on the prospectively collected data on 310 consecutive patients who underwent shoulder arthroscopic procedures for one or other reason at our hospital between January 2013 and December 2013. The Porcellini test was performed in all patients by two independent examiners before the arthroscopic procedures. In an attempt to reduce the bias, we excluded patients who underwent previous surgery on the affected shoulder, patients with acute fractures or dislocations, and patients with adhesive capsulitis. There were 194 males and 116 females with their mean age 48.6 years (range 16–77 years). The spectrum of preoperative diagnoses included anterior instability ( $n = 25$ ), posterior instability ( $n = 12$ ), calcific tendinitis ( $n = 10$ ), rotator cuff tears ( $n = 229$ ), bony Bankart lesion ( $n = 8$ ), SLAP lesions



**Fig. 2** Radiographic verification of the “Porcellini” test. **a** Posteriorly translated humeral head during first maneuver. **b** Posterior translation of humeral head prevented on account of the moderate anterior force

exerted by the examiner's thumb during second maneuver. The blue dot represents the center of the humeral head, and the red line is perpendicular to the glenoid axis through its center

( $n = 2$ ), multidirectional instability ( $n = 3$ ), suspected isolated posterior labral lesions ( $n = 15$ ), loose body ( $n = 3$ ), and degenerative arthritis ( $n = 3$ ). The complete arthroscopic evaluation of the glenohumeral and subacromial space was done by the senior surgeon who was blinded to the test results. The arthroscopic findings were recorded and used as standard of reference. All the posterior labral lesions located from 2 to 7 o'clock position for the left shoulder and 5 to 10 o'clock position for the right shoulder were noted (Fig. 3) and classified according to the Kim et al. classification [13, 14].

Afterward, we sought to compare the accuracy of Porcellini test with other established tests which included O'Brien's test [6], the Kim test [7], the Jerk test [6], and the Load and Shift test [8]. For this purpose, we conducted a cohort study on 91 consecutive patients who underwent shoulder arthroscopic procedures for one or other reason at our hospital. Similar exclusion criteria as mentioned before were applied for this cohort also. All the patients were examined before the arthroscopic procedures for Porcellini test and other aforementioned tests by two independent examiners. There were 57 males and 34 females with their mean age 50.57 years (range 15–79 years). The preoperative diagnoses included anterior instability ( $n = 7$ ), posterior instability ( $n = 4$ ), calcific tendinitis ( $n = 3$ ), rotator cuff tears ( $n = 71$ ), bony Bankart lesion ( $n = 2$ ), multidirectional instability ( $n = 2$ ), paraglenoid cyst ( $n = 1$ ), and synovial cyst ( $n = 1$ ). The complete arthroscopic evaluation was done by the senior surgeon who was blinded to the test results, and the arthroscopic findings were used as standard of reference.

### Statistical analysis

The Porcellini test was evaluated for its accuracy in terms of sensitivity, specificity, positive and negative predictive values for diagnosing posterior labral tears. Similarly, the



**Fig. 3** Posterior labral tear on arthroscopic evaluation

accuracy of aforementioned established tests was determined and compared with the proposed test. The interexaminer reliabilities of the test results were evaluated using intraclass correlation coefficients (ICCs).

### Results

The radiological verification of the test conferred the anatomical basis for the mechanism of our proposed test. In the retrospective case-controlled analysis in first part of the study, out of 310 shoulders, 25 shoulders (incidence of 8 %) were found to have posterior labral tears on arthroscopic evaluation. There were eight type I, ten type II, five type III, and two type IV posterior labral lesions. Twenty-seven shoulders had a positive Porcellini test result, and out of which 25 (true positives) had a posterior labral lesion, while 2 (false positives) had normal posterior labrum (Table 2). There were no false negative test results. Thus, Porcellini test conferred the sensitivity of 100 %, specificity of 99.3 %, the positive predictive value of 92.6 %, and the negative predictive value of 100 %. The interexaminer reliability was found to be  $>0.80$  which was satisfactory.

In the cohort analysis in latter part of the study, out of 91 shoulders, 8 shoulders (incidence of 9 %) were found to have posterior labral tears on arthroscopic evaluation. Porcellini test was positive in nine shoulders, and out of which eight (true positives) had a posterior labral lesion, while one (false positive) had normal posterior labrum. There were no false negative test results. Thus, in this part of the study, it showed the sensitivity of 100 %, specificity of 98.8 %, the positive predictive value of 88.9 %, and the negative predictive value of 100 % (Table 3). Twelve shoulders had a positive O'Brien's test, and out of which six (true positives) had a posterior labral lesion, while six (false positives) had normal posterior labrum. There were two false negative test results. Thus, accuracy results of the O'Brien's test revealed the sensitivity of 75 %, specificity of 92.8 %, and the positive and negative predictive values of 50 and 97.5 %, respectively. Kim test was positive in nine shoulders, and out of which six (true positives) had a posterior labral lesion, while three (false positives) had normal posterior labrum. With two false negative results, the Kim test showed the sensitivity of 75 %, specificity of 96.4 %, and the positive and negative predictive values of 66.7, and 97.6 %, respectively.

Data calculations for the accuracy results of the Jerk test for posterior labral tears revealed the sensitivity of 62.5 %, specificity of 96.4 %, and the positive and negative predictive values of 62.5 and 96.4 % with 5, 3, and 3 true positive, false positive, and false negative results, respectively. At last, the Load and Shift test had the sensitivity of

**Table 2** Accuracy results of the Porcellini test in diagnosing posterior labral tears in first part of the study (case-controlled analysis)

Test outcome	Posterior labrum torn	Posterior labrum normal	Predictive values
Porcellini test +ve	25	2	PPV 92.6 %
Porcellini test -ve	0	282	NPV 100 %
	Sensitivity 100 %	Specificity 99 %	<i>n</i> = 310

PPV positive predictive value, NPV negative predictive value

**Table 3** Comparison of accuracy results of all the tests included in the second part of the study (cohort analysis)

Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Porcellini test	100	98.8	88.9	100
O'Brien's test	75	92.8	50	97.5
Kim test	75	96.4	66.7	97.6
Jerk test	62.5	96.4	62.5	96.4
Load and Shift test	37.5	89.2	25	93.7

PPV positive predictive value, NPV negative predictive value

37.5 %, specificity of 89.2 %, the positive predictive value of 25 %, and the negative predictive value of 93.7 % with 3, 9, and 5 true positive, false positive, and false negative results, respectively. Among all the tests, Porcellini test showed highest accuracy test results (Table 3). Again, the interexaminer reliability for all test results was found to be >0.80 which was satisfactory.

## Discussion

Despite the increasingly recognized role of posterior labral tears with or without instability of the shoulder as a cause of disability in the athletic population [2, 15], its preoperative diagnosis remains challenging. Indeed, no existing single clinical test can diagnose this entity with high accuracy and reliability. Hence, we sought to devise and present the results of our newly proposed test for diagnosing reliably and accurately the posterior labral tears of the shoulder.

Our study results support our first hypothesis that Porcellini test showed high accuracy and reproducibility in diagnosing posterior labral tears. In accordance with our optimism, in both the parts of the study, it depicted 100 % sensitivity and 99 % specificity which mean that every shoulder with posterior labral tear will have this test positive. The negative predictive value of 1 signifies that if this test is negative in a particular shoulder, it is unlikely to find posterior labral tear in that shoulder. Moreover, its similar sensitivity and specificity results in both parts of the study certify its high reproducibility and simplicity. Furthermore, this is supported by the finding that the interexaminer reliabilities for the test results were >0.80 in both the parts of the study.

The study results also support our second hypothesis that its accuracy was higher than every other test included

in this study. Although the Kim test has been proposed to be a reliable test for posteroinferior labral tears with its sensitivity and specificity of 80 and 94 %, respectively, the authors themselves have concluded that it is more sensitive for detecting the predominantly inferior component of the lesion [7]. To diagnose the predominantly posterior labral lesion and hence to increase the sensitivity, the authors have proposed its use in conjunction with the Jerk test [7]. When these two tests were used together for detecting the posteroinferior labral lesions, the sensitivity increased to 97 % which is comparable to that offered by Porcellini test alone. Further, the original description of the O'Brien's test was in reference to the diagnosis of SLAP lesions and acromioclavicular joint (ACJ) pathologies. However, its reinterpretation for posterior labral lesions was found to have high sensitivity of 83 % and the positive predictive value of 0.9 [16]. Although superior than the O'Brien's test results observed in our study, these results are still inferior compared to the accuracy results of Porcellini test which showed sensitivity of 100 % and the positive predictive value of 92.6 %. Also, the accuracy results of Jerk test and Load and Shift test were found to be far inferior to that of Porcellini test in our study.

Furthermore, the Jerk test has been described as a diagnostic test for posterior instability and its principal purpose was detection of the posterior instability by demonstrating posterior clunk of the humeral head [17]. However, it was shown that for diagnosing the labral lesions, the pain component was more important than the clunk because the painful clunk in the jerk test had a high correlation with a posterior labral lesion [18]. Likewise, the Load and Shift test is also described for the evaluation of instability in which the amount of humeral head translation is assessed [8]. This fact along with the low accuracy results of the Jerk test and Load and Shift test questions

their use for detecting posterior labral tears. For the Kim test, the authors have emphasized the importance of a firm axial compression force to the glenoid surface by the humeral head during the test. However, in our practice, sometimes we found it difficult to maintain firm axial compression force, to diagonally elevate the arm, and to apply a backward and downward force to the proximal arm, all at the same time while performing this test. In O'Brien's test, the differentiation between the diagnoses of labral tear and ACJ pathologies is made depending on the location of pain perceived. Pain localized to the ACJ or on top of the shoulder is diagnostic of ACJ pathology, whereas pain or painful clicking felt inside the glenohumeral joint is indicative of labral pathology. However, to make it more easy, in our proposed test, if the pain or weakness of first maneuver is reduced or eliminated in second maneuver, the diagnosis of posterior labral tear is made; while, if the pain persists in second maneuver also, then it suggests ACJ pathology. Also, there will be no weakness throughout the test in case of ACJ pathology. Furthermore, the Porcellini test is easy to perform even in anxious and apprehensive patients, as no force is applied by the examiner over patient's arm like in other tests.

We believe that our proposed test is a more physiological test for the diagnosis of posterior labral tears. This is evident from the fact that the maximum posterior capsular tension applying the compressive force on the torn labrum occurs in the position of forward flexion, adduction and internal rotation [6, 19–23]. When the patient actively elevates the arm against the resistance, the line of pull of deltoid causes posterior translation of the humeral head causing further compression of the torn labrum [16]. In the second maneuver, when the humeral head is supported posteriorly with examiner's thumb, it off-loads the labrum resulting in partial or complete pain relief with gain in the strength. The examiner tries to relocate the humeral head in the glenoid cavity similar to that in the anterior apprehension relocation test for anterior instability. Additional advantage of this test is that, as the examiner stabilizes the scapula with one hand during both the parts of the test, the possibility of scapular dyskinesis as a cause of disability is also excluded. Thus, with the early and accurate diagnosis of posterior labral tears, early rehabilitative approach to restore stability, range of motion and function of shoulder joint might be effective, especially in non-athletes, as it is in first-time anterior shoulder dislocation [24].

Our study has a limitation that we did not perform the separate analyses in shoulders with "isolated posterior labral tear" and in shoulders with "associated lesions" which could have given the additional information about impact of associated lesions on our test results. The associated lesions like massive rotator cuff tears will definitely affect the test results [25]. Nevertheless, we believe that by including the

patients with various shoulder pathologies, we might have neutralized this impact. On the other hand, our study has several strengths. The use of arthroscopic confirmation as a reference standard yields substantial strength to our study. Moreover, the arthroscopic evaluation done by the senior surgeon who was blinded for the preoperative test results helps to avoid observational bias. Finally, we tried to eliminate verification bias by the inclusion of all patients who underwent the diagnostic tests [26].

To conclude, the "Porcellini" test is a highly accurate, reproducible, easy to perform, and reliable test for the diagnosis of posterior labral tears of shoulder which would be extremely helpful in preoperative planning for the successful management in this small subset of patients.

#### Compliance with ethical standards

**Conflict of interest** All authors hereby declare that they have no conflicts of interest.

**Ethical approval** All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in this study.

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