

Which is More Useful, the "Full Can Test" or the "Empty Can Test," in Detecting the Torn Supraspinatus Tendon?

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The purpose of this study was to determine the clinical usefulness of the full can and empty can tests for determining the presence of a torn supraspinatus tendon. The two tests were performed in 143 shoulders of 136 consecutive patients. In each test, the muscle strength was determined by manual muscle testing, and the presence of pain during the maneuver was recorded. We interpreted the tests as positive when there was 1) pain, 2) muscle weakness, or 3) pain or muscle weakness or both. Shoulders were examined by high-resolution magnetic resonance imaging with 95% accuracy for full-thickness rotator cuff tears. There were 35 shoulders with full-thickness tears of the supraspinatus tendon. The accuracy of the tests was the greatest when muscle weakness was interpreted as indicating a torn supraspinatus tendon in both the full can test (75% accurate) and the empty can test (70% accurate). However, there was no significant difference between the accuracy of the tests when this criterion was used. Pain was observed in 62 shoulders (43%) during the full can test and in 71 shoulders (50%) during the empty can test, but the difference was not statistically significant. Muscle weakness should be interpreted as indicative of supraspinatus tendon tear. Using this indicator, both tests are equivalent in terms of accuracy, but considering pain provocation, the full can test may be more beneficial in the clinical setting.

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The supraspinatus tendon is usually involved in tears of the rotator cuff.[4] Jobe and Moynes[9] report that the function of the supraspinatus muscle can be isolated to some degree with the arm in 90 [degrees] of elevation in the scapular plane (scaption) and in full internal rotation ("empty can," that is, similar to the position of the shoulder when emptying a can). Muscle testing against resistance in this position, called the supraspinatus test, demonstrates a weakness secondary to a tear of the supraspinatus tendon or pain associated with rotator cuff impingement.[8] The interpretation of this test is somewhat controversial. Some interpret this test as positive for a tear of the supraspinatus tendon when there is weakness or pain (Refs. 7, 14; R. E. Glousman, unpublished data, 1987), or when there is weakness or pain or both,[3] whereas others recognize this test as a pure manual muscle test.[5,11]

The first purpose of this study was to determine whether pain should be used for interpretation of this test. If pain is the symptom to be assessed, there is no reason to eliminate the pain. On the other hand, if pain is not to be assessed, a less painful testing position may be desirable. Kelly et al.[11] proposed a new test to assess the function of the supraspinatus tendon with the arm in 90 [degrees] of scaption and 45 [degrees] of external rotation (full can). They report that the EMG activities of the supraspinatus muscle in both the full can and empty can tests were similar but that the full can test was less pain provocative. This test position was also recommended for rehabilitation of the supraspinatus muscle.[10] However, the diagnostic value of the full can test has not been reported in the literature. Therefore, the second purpose of this study was to determine the clinical usefulness of the full can test in comparison with the classic empty can test in detecting the torn supraspinatus tendon.

MATERIALS AND METHODS

Between May 1996 and July 1997, 143 shoulders of 136 consecutive patients with various shoulder symptoms were referred to our institute. There were 105 men (110 shoulders) and 31 women (33 shoulders), aged from 13 to 80, with an average age of 43 years.

The full can test[11] and empty can test[9] were performed to assess the integrity of the supraspinatus muscle. For each test, the muscle strength was determined by manual muscle testing scaled from 0 to 5: 5, normal amount of resistance to applied force; 4, lesser amount of resistance than 5 but greater than 3; 3, ability to move the segment (the arm) through its range of motion against gravity; 2, ability to move the segment through its range of motion with gravity eliminated; 1, presence of a contraction in the muscle without joint motion; 0, no muscle contraction.[2] When the strength was grade 4 or less, we determined that there was muscle weakness. The presence or absence of pain during the maneuver was also recorded.

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After the physical examinations, all the shoulders were examined by MRI. Using a 1.5-T MR imager (Signa; GE Medical Systems, Milwaukee, Wisconsin), spin-echo T1-weighted images (TR/TE [repetition time/echo time] = 600/23 msec) and fast spin-echo T2-weighted images (TR/TE = 4000/92.2 msec) in the coronal and sagittal planes were obtained in 3-mm thick 1-mm gap slices with 10- to 15-cm fields-of-view and 256 X 128 pixel matrix size. A combination of dual phased array coils and a small field-of-view achieved high-resolution MRI scans.[16] High signal intensity occupying the full-thickness layer of the rotator cuff tendon on T2-weighted image was diagnosed as a full-thickness tear. The diagnostic accuracy of this MRI system for full-thickness tears of the rotator cuff was 95%. The torn tendon was also determined by the location of high signal intensity on T2-weighted images in both the coronal and sagittal planes.[15]

From the physical examinations and MRI findings, we calculated the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the full can and empty can tests for full-thickness tears of the supraspinatus tendon. Sensitivity is defined as the percentage of times that the test is positive in patients who have the pathologic entity, that is, the supraspinatus tendon tear. It was calculated by dividing the number of true-positive results by the total number of true-positive and false-negative results. Specificity is defined as the percentage of times that the test is negative in patients who do not have the pathologic entity. It was calculated by dividing the number of true-negative results by the total number of true-negative and false-positive results. Positive predictive value is defined as the likelihood that a patient for whom the test is positive actually has the lesion. It was calculated by dividing the number of true-positive results by the total number of true-positive and false-positive results. Negative predictive value is defined as the likelihood that a patient for whom the test is negative really does not have the lesion. It was calculated by dividing the number of true-negative results by the total number of true-negative and false-negative results. Accuracy is defined as the percentage of times that the test is positive in patients with the lesion and the percentage of times that the test is negative in patients without the lesion. It was calculated by dividing the number of true-positive and true-negative results by the total number of results.

We interpreted the tests as positive when either 1) the examination induced pain, 2) the muscle strength was at the level of 4 or less, or 3) there was pain or muscle weakness or both. The sensitivity, specificity, and accuracy of the tests using these three different criteria were compared with use of the Cochran Q test because these parameters were calculated based on dependent samples (those with supraspinatus tendon tear, those without the tear, all cases). On the other hand, the positive and negative predictive values were calculated based on independent samples, and thus the Kruskal-Wallis test was used to compare these parameters in each test. For each criterion, the sensitivity, specificity, and accuracy were compared between the full can and empty can tests using the McNemar's test because these parameters were calculated based on dependent samples. For the comparison of positive and negative predictive values, the chi-square test was used instead, because these values were calculated based on independent samples. The statistical significance was set at the 5% level.

RESULTS

There were 35 shoulders with full-thickness tears of the rotator cuff. The supraspinatus tendon was involved in all 35 shoulders (Table 1).

TABLE 1 Site of Rotator Cuff Tears

Torn tendons	No. of shoulders
Supraspinatus	19
Supraspinatus + infraspinatus	11
Supraspinatus + infraspinatus + subscapularis	5
Total	35

The diagnostic value of the full can and empty can tests is summarized in Table 2. In both the full can and empty can tests, the sensitivity was the greatest (86% and 89%, respectively) when interpreted using pain or muscle weakness or both as the criteria, whereas the specificity was the greatest (74% for the full can test, 68% for the empty can test) when the results were interpreted using only muscle weakness as the criterion. There were no significant differences in the positive and negative predictive values among the three criteria. The accuracy was the greatest when muscle weakness

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was used for interpretation in both the full can test (75%, $P = 0.0016$) and the empty can test (70%, P [is less than] 0.0001). Comparison between the two tests revealed that the specificity and accuracy were greater in the full can test when the results were interpreted using pain. Using muscle weakness, which gave the greatest accuracy in both tests, the full can test also showed greater specificity and accuracy than the empty can test, but the differences were not statistically significant ($P = 0.0707$). Pain was observed in 62 shoulders (43%) during the full can test and in 71 shoulders (50%) during the empty can test ($P = 0.28$).

TABLE 2 The Diagnostic Values of the Full Can and Empty Can Tests for Detecting a Torn Supraspinatus Tendon

Test	Sensitivity	Specificity
Full can test		
Pain	23/35 (66%)	69/108 (64%)
Muscle weakness	27/35 (77%)	80/108 (74%)
Pain or muscle weakness	30/35 (86%)	62/108 (57%)
or both		
P values	0.0247 (a)	[is less than] 0.0001 (a)
Empty can test		
Pain	22/35 (63%)	59/108 (55%)
Muscle weakness	27/35 (77%)	73/108 (68%)
Pain or muscle weakness or both	31/35 (89%)	54/108 (50%)
P values	0.0116 (a)	[is less than] 0.000 (a)
Comparison between full can and empty can tests		
P values in pain	1.0 (c)	0.0341 (c)
P values in muscle weakness	1.0 (c)	0.0707 (c)
P values in pain or muscle weakness or both	0.48 (c)	0.0525 (c)
	Positive predictive value	Negative predictive value
Full can test		
Pain	23/62 (37%)	69/81 (85%)
Muscle weakness	27/55 (49%)	80/88 (91%)
Pain or muscle weakness or both	30/76 (39%)	62/67 (93%)
P values	0.38 (b)	0.30 (b)
Empty can test		
Pain	22/71 (31%)	59/72 (82%)
Muscle weakness	27/62 (44%)	73/81 (90%)
Pain or muscle weakness or both	31/85 (36%)	54/58 (93%)
P values	0.76 (b)	0.20 (b)
Comparison between full can and empty can tests		
P values in pain	0.46 (d)	0.59 (d)
P values in muscle weakness	0.55 (d)	0.86 (d)
P values in pain or muscle weakness or both	0.70 (d)	0.90 (d)
	Accuracy	
Full can test		
Pain	92/143 (64%)	
Muscle weakness	107/143 (75%)	
Pain or muscle weakness	92/143 (64%)	

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or both	
P values	0.0016 (a)
Empty can test	81/143 (57%)
Pain	100/143 (70%)
Muscle weakness	85/143 (59%)
Pain or muscle weakness or both	
P values	[is less than]
	0.000 (a)
Comparison between full can and empty can tests	
P values in pain	0.0292 (c)
P values in muscle weakness	0.0707 (c)
P values in pain or muscle weakness or both	0.0668 (c)

- (a) Cochran's Q test.
- (b) Kruskal-Wallis test.
- (c) McNemar's test.
- (d) Chi-square test.

DISCUSSION

The first point we learned from this study is that muscle weakness should be used to interpret the full can and empty can tests. As both muscle weakness and pain are the common symptoms of rotator cuff tears, the existence of muscle weakness or pain or both in these tests is thought to be a positive sign to indicate a tear of the supraspinatus tendon (Refs. 3, 7, 14; R. E. Glousman, unpublished data, 1987). This study demonstrated that when the criterion for interpreting these tests was muscle weakness, the tests were more accurate in indicating a supraspinatus tendon tear than when other criteria were used. We agree with those who recognize these tests as purely manual muscle tests.[5,11]

If these tests are to be assessed only by muscle weakness, should we eliminate pain? Pain modifies the muscle strength.[1,6] In an earlier study at our institution, isokinetic strength of scaption after tears of the supraspinatus tendon increased from 56% of the contralateral shoulder before a pain block was administered to 73% after the block was administered.[6] Because of this effect of pain on muscle strength, there is a concern about the reliability of the empty can test, in which internal rotation of the humerus at 90 [degrees] of scaption results in the impingement position. Kelly et al.[11] expressed their concern that such positional pain may decrease the accuracy of the manual muscle test of the supraspinatus. Hertel et al.[5] also mentioned that the empty can test is biased by the positional pain provocation even in the presence of an intact cuff. In other words, pain has the disadvantage of decreasing the specificity of the test. On the other hand, we sometimes experience that a 10% to 20% decrease of strength cannot be detected by the manual muscle test in patients who are very powerful. That is, if a person's decreased strength is still larger than the examiner's strength, it is assessed as level 5. In such cases, pain may make it possible to detect muscle weakness that cannot be detected without pain. Thus, pain has the potential advantage of increasing the sensitivity, although this was not proven in this study. As pain has both positive and negative effects on diagnostic accuracy, a less painful test may not always be better in terms of diagnostic accuracy. However, this study demonstrated for the first time that the full can and empty can tests were equally accurate in detecting the torn supraspinatus tendon. When accuracy is the same, then the less painful test is more desirable. In our series, pain provocation was more common in the empty can test than in the full can test, although the difference was not statistically significant. We therefore concluded that the full can and empty can tests are equivalent in terms of diagnostic accuracy, but considering pain provocation, the full can test may be more beneficial in the clinical setting.

Another factor that affects the accuracy of these tests is muscle atrophy. Because muscle atrophy is directly related to muscle strength, it needs to be discussed despite the fact that it was not measured in this study. The calculated

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contribution of the supraspinatus tendon to scaption is less than 10%,[13] which seems difficult to be detected by manual muscle testing. However, in our previously mentioned study,[6] the measured contribution of the supraspinatus tendon to scaption was 19% to 33% after the pain block. This discrepancy between the calculation and in vivo measurements may be explained by atrophy of the muscles around the shoulder. Quantitative assessment of muscle atrophy in shoulders with rotator cuff tears has been reported based on MRI in patients[17,18] and on volume measurements in cadaveric shoulders.[12] According to Kido et al.,[12] the average decrease in muscle volume of cuff-tear shoulders was 19% to 30% in the rotator cuff muscles and 29% in the deltoid muscle. Muscle atrophy observed in cuff-tear shoulders is likely to increase the sensitivity, but atrophy in shoulders with an intact cuff is likely to decrease the specificity of these tests.

We used MRI to assess the integrity of the rotator cuff tendon. One may dispute the validity of using MRI as the definitive diagnostic tool. There are two points to be mentioned. First, our MRI system allows high-resolution MRI scans with 95% accuracy for full-thickness tears of the rotator cuff because of the use of dual phased array coils and a small field-of-view. In this series, 21 of 35 shoulders with MRI-evident supraspinatus tendon tears were surgically treated. During surgery, they were all confirmed to have full-thickness tears of the supraspinatus tendon. Second, when we compare the shoulders with rotator cuff tears confirmed during surgery with those with intact rotator cuffs also confirmed during surgery, the subjects are only those undergoing surgical treatment. This is a very specific group of patients among those who visit the shoulder clinic. Accordingly, the percentage of rotator cuff tears is much higher than that in the outpatient population. This significantly affects our assessment of the diagnostic value of these tests. Although the diagnostic accuracy of MRI is a little less than that of surgical findings, the results we presented may well reflect the diagnostic value of these tests in the clinical setting.

In conclusion, muscle weakness alone should be used as a criterion to interpret the results of the full can and empty can tests. Both tests are equivalent in terms of diagnostic accuracy, but considering pain provocation, the full can test may be more beneficial in the clinical setting.

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