The Clinical Diagnosis of Subcutaneous Tear of the Achilles Tendon : A Prospective Study in 174 Patients

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The Clinical Diagnosis of Subcutaneous Tear of the Achilles Tendon

A Prospective Study in 174 Patients

Nicola Maffulli,* MD, MS, PhD, FRCS(Orth)

From the Department of Orthopaedic Surgery, University of Aberdeen Medical School, Aberdeen, Scotland

ABSTRACT

A study to determine the sensitivity, specificity, and positive and negative predictive values of several clinical diagnostic tests of subcutaneous Achilles tendon rupture was performed during a 13-year period. There were 174 patients with clinical diagnosis of unilateral complete subcutaneous Achilles tendon tear and 28 patients with unilateral suspected but no actual Achilles tendon tear. The following tests were used: palpation, calf squeeze, Matles, Copeland, and O'Brien. Palpation of the gap was the least sensitive clinical test with the patient awake (0.73), increasing to 0.81 when the test was performed under anesthesia; the Copeland and O'Brien tests showed a sensitivity of 0.8. Both the calf squeeze and Matles tests were significantly more sensitive than the other tests (0.96 and 0.88, respectively; $0.022 < P < 0.05$). All tests showed a high positive predictive value, with no statistically significant difference between the various tests. In the 28 patients with no evidence of a subcutaneous Achilles tendon tear on imaging, the tests showed a high capability to detect that the Achilles tendon was intact (gap palpation specificity, 0.89; calf squeeze test specificity, 0.93; Matles test specificity, 0.85). Whichever tests were performed, at least two of them were positive for a subcutaneous tear of the Achilles tendon in all patients in this study.

The Achilles tendon is the largest tendon in the human body, and the one that most frequently undergoes a complete subcutaneous tear.[7] The diagnosis of a torn Achilles tendon is not easy for nonspecialists; patients with such tears that may be initially misdiagnosed accordingly reach orthopaedic surgeons at different stages after injuries.[17]

Clinical history may be deceptive, but careful physical examination gives precious information. When examined soon after the injury, a gap—indicative of a tear in the substance of the tendon—can be seen and palpated. With increased time after the tear, the gap may be obliterated by edema, which makes palpation unreliable. Also, in the early stages, edema and bruising may not be apparent, and plantar flexion and even standing on tiptoes may still be possible through the action of the tibialis posterior and the peronei muscles.

Radiography,[4] ultrasonography,[11] and magnetic resonance imaging (MRI)[6,8] have been used to diagnose Achilles tendon tears. However, soft tissue radiography can be of little value, ultrasonography is open to subjective interpretation, and MRI is expensive, not always readily available, and may not be tolerated well by some patients.

Numerous clinical tests have been described to aid in the diagnosis of Achilles tendon tears.[5,13,14,18–20] To date, however, there has been no study that systematically compared the various clinical tests used for the diagnosis of subcutaneous Achilles tendon tears. In this article, I report my personal experience in this field.

PATIENTS AND METHODS

This study spans the whole period of my training, from September 1983 to March 1996. During this period, I observed and treated under supervision or assisted in the treatment of 174 patients (149 men and 25 women) with unilateral (95 left tears) complete subcutaneous Achilles tendon tears. All patients gave informed consent to be examined, to undergo the tests described here, and to be treated. The management of the injury varied according to the consultant (attending physician) in charge of the pa-

* Address correspondence and reprint requests to Nicola Maffulli, MD, MS, PhD, FRCS (Orth), Department of Orthopaedic Surgery, University of Aberdeen Medical School, Polwarth Building, Foresterhill, Aberdeen AB25 2ZD, Scotland.

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tients: 22 patients were treated conservatively, 19 patients underwent percutaneous repair, and in the remaining 133 patients the tendons were repaired using an open procedure. After physical examination, I applied casts for conservative treatment of 10 of the 22 patients for whom such management was elected. I personally performed a percutaneous repair in 13 patients[9,14,16] or an open repair in 99 patients,[12] and I assisted in the relevant operations in all other cases.

All patients were examined when admitted or in the immediate preoperative period, with the patient fully awake. The tests described here were repeated on the operating table, with the patients under general anesthesia (105 cases, 101 of which underwent an open repair), spinal anesthesia (39 cases, 35 of which underwent open repair), or local anesthesia (8 cases, all in the percutaneous repair group). In all patients, the contralateral uninjured tendon was tested and used as an internal control. The contralateral tendon was clinically normal in all patients. Also, in all patients for whom it applied, during anesthesia, the tests were performed before the tourniquet was inflated.

The physical examination and the various tests described in this study were performed with the patients lying prone, and the ankles clear of the examination couch or the operating table. Although it would have been desirable that each examiner (the consultant in charge of the case and the author) had performed all diagnostic tests twice, this was not always feasible. Also, one examiner was not routinely blinded to the results of a given test performed by the other examiner. Therefore, given the large number of consultant orthopaedic surgeons performing the tests (13 surgeons), and the nonsystematic repeated testing, the data regarding differences between the consultants in charge of the patients and the author were not analyzed further.

Tests Used in This Study

Palpation. The examiner gently palpates the course of the tendon. The gap is classified as present or absent. The test was performed in all patients by the author and by the consultant in charge of the patient.

Calf Squeeze Test. Originally described by Simmonds,[18] and subsequently by Thompson and Doherty [20] and again by Thompson,[19] in this test the examiner gently squeezes the patient's calf muscles with the palm of his or her hand. If the Achilles tendon is intact, plantar flexion occurs in the ankle. If the Achilles tendon is torn, the ankle remains still, or only minimal plantar flexion occurs. The test was performed in all patients by the author and by the consultant in charge of the patient.

Matles Test. While awake, patients are asked to actively flex their knees to 90°. When the patients are anesthetized, the examiner passively flexes both knees to 90°. In both instances, the position of the ankles and feet is observed during flexion of the knee. If the foot on the affected side falls into neutral or into dorsiflexion, an Achilles tendon tear is diagnosed. On the uninjured side, the foot remains in slight plantar flexion when the knee is flexed to 90°.[13] The test was performed in 107 patients, 91 of whom were managed operatively (14 by percutaneous repair). In the 91 patients who underwent operation, the test was performed by the author and by the consultant in charge of the patient in 73 instances (12 percutaneous repairs).

Copeland Test. With the patient prone, a sphygmomanometer cuff is placed around the middle of the calf and inflated to 100 mm Hg, with the ankle placed in passive plantar flexion by the examiner. The examiner then dorsiflexes the ankle. If the Achilles tendon is intact, dorsiflexion produces a rise in pressure of between 35 and 60 mm Hg. If the tendon is torn, little or no pressure rise is seen.[5] The test was performed in 48 patients, none of whom were treated conservatively. As patients reported significant discomfort in their affected ankles, it was decided not to perform the test with the patient awake but to limit testing while patients were under anesthesia. Therefore, 15 patients undergoing open repair received the test both awake and during anesthesia and 33 patients, 29 of whom underwent an open repair, during anesthesia only. This test was always performed by the author only.

O'Brien Test. This test was performed on 17 patients, all but 2 of whom underwent open repair. The test was performed when the patients were either under general or spinal anesthesia. With the patient prone, a 21-gauge needle is inserted at a right angle through the skin of the calf, just medial to the midline, 10 cm proximal to the superior border of the calcaneus. The needle is inserted only until the tip is just within the substance of the tendon. The foot is then passively put through alternately dorsiflexion and plantar flexion. Two responses may occur. The needle may swivel so that it points in the direction opposite to the motion of the ankle (i.e., when the ankle is in dorsiflexion, the needle points distally). This indicates that the tendon is intact in the portion distal to the needle insertion point. The other possible response is that the needle does not move, or moves slightly in the same direction as the motion of the ankle (i.e., when the ankle is in dorsiflexion, the needle does not move, or points slightly proximally). In this second instance, the Achilles tendon has lost its continuity between the needle and its insertion.[14] This test was always performed by the author only.

Time Between Injury and Presentation

Patients were divided into groups according to the time, in days, between the injury causing the tendon tear and presentation. They were classified as presenting on the day of injury (98 patients), between 1 and 3 days (45 patients), between 4 and 7 days (14 patients), between 8 and 14 days (7 patients), and between 14 and 28 days (10 patients).

Patients Without Achilles Tendon Tears

During the study period, I examined 28 patients (21 men and 7 women) with a unilateral (16 left ankles) injury and acute pain in the posterior aspect of the lower leg. In all cases, a diagnosis of Achilles tendon tear had been made by an accident and emergency officer, and, on clinical grounds, excluded by the author. In 23 patients, a high-resolution real-time ultrasound scan, and, in the remaining 5 patients, an MRI scan excluded an Achilles tendon tear. These patients were examined in the same manner as previously described, by taking a complete clinical history, and by palpation, calf squeeze, and Matles tests. I was not aware of the imaging diagnosis before performing the tests.

Data Management

Data were collected by hand and transferred to a commercially available spreadsheet on a personal computer. Descriptive statistics were calculated. Data for each test were coded as binary items (present or absent). For each test, specificity, sensitivity, positive predictive value, and negative predictive value were calculated.[2,3] In the calculation of sensitivity of the various clinical tests, the dubious results were considered as false-negative for the patients in whom an Achilles tendon tear had been diagnosed. The dubious results were considered as false-positive when positive predictive values were calculated. In the patients in whom imaging and clinical examination excluded an Achilles tendon tear, the dubious results were considered as false-positive when calculating specificity of the various clinical tests, and as false-negative when negative predictive values were calculated. Data were analyzed using McNemar's test for paired proportions.[1]

RESULTS

Patients

Patients treated conservatively were significantly older (48.1 years; SD, 13.2) than patients treated with a percutaneous repair (42.5 years; SD, 11.6; $P = 0.03$) or with an open repair (38.4 years; SD, 10.5; $P = 0.01$). Patients who underwent an open repair were not significantly younger than patients receiving a percutaneous repair ($P = 0.06$).

Time Between Injury and Presentation

There was no significant temporal effect on the sensitivity and predictive values of the various tests, except in the case of palpation of the gap, when a nonsignificant trend toward inability of the examining surgeon to detect the gap during examination with the patient awake was noted.

Clinical Tests

The descriptive results of the various tests performed in patients in whom a subcutaneous tear of the Achilles tendon was diagnosed are given in Table 1. As direct evidence of a torn tendon was produced only in the 133 patients who underwent an open repair, sensitivity and predictive values for the various tests were calculated for such patients only (Table 2). At open repair, only 2 of the 133 patients undergoing open repair had a partial tear of the tendon. Both of these patients had dubious responses to the Matles test. In both patients, the tear was repaired, and the postoperative management was the same as in patients with complete tears. The least sensitive of the clinical tests was the palpation of the gap with the patient awake, which showed a sensitivity of 0.73, increasing to 0.81 when the examination was performed again under anesthesia. The Copeland test and the O'Brien test showed a similar sensitivity (about 0.8). Except in the calf squeeze test, where it did not change, the sensitivity between examination performed with the patient awake and under anesthesia increased, but the difference did not reach statistical significance. The calf squeeze test and the

TABLE 1
Results of the Various Tests

Test and patient state	Closed (N = 22)			Percutaneous (N = 19)			Open (N = 133)		
	Positive[a]	Negative[b]	Dubious	Positive	Negative	Dubious	Positive	Negative	Dubious
Gap (N = 174)									
Awake	17	2	3	13	4	2	97	15	21
Anesthesia	NA	NA	NA	15	3	1	108	6	19
Calf squeeze (N = 174)									
Awake	20	0	2	17	1	1	128	2	3
Anesthesia	NA	NA	NA	19	0	0	128	0	5
Matles (N = 107)									
Awake	13	1	2	12	1	1	68	3	6
Anesthesia	NA	NA	NA	12	1	1	73	2	2
Copeland (N = 48)									
Awake	NA	NA	NA	NA	NA	NA	11	2	1
Anesthesia	NA	NA	NA	3	0	1	36	3	5
O'Brien (N = 17)									
Awake	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anesthesia	NA	NA	NA	2	0	0	12	1	2

[a] Rupture diagnosed.
[b] No rupture diagnosed.

TABLE 2
Sensitivity and Positive Predictive Value of the Tests in the 133 Patients Who Underwent Open Repair of the Achilles Tendon Tear

Test and patient state	Sensitivity	Positive predictive value
Gap (N = 133)		
Awake	0.73	0.82
Anesthesia	0.81	0.85
Calf squeeze (N = 133)		
Awake	0.96	0.98
Anesthesia	0.96	0.96
Matles (N = 77)		
Awake	0.88	0.92
Anesthesia	0.94	0.97
Copeland (N = 44)		
Awake	0.78	0.92
Anesthesia	0.81	0.88
O'Brien (N = 17)		
Awake	NA	NA
Anesthesia	0.80	0.85

Matles test showed a sensitivity close to 0.9, and higher than this value when the test was performed with the patient under anesthesia. Both the calf squeeze test and the Matles test were significantly more sensitive than the other tests ($0.022 < P < 0.05$).

All tests showed a high positive predictive value, with the calf squeeze, Matles, and Copeland tests showing a value of at least 0.90. There was no statistically significant difference between the various tests, although the difference between the ones with the best positive predictive value (the calf squeeze test performed with the patient awake and the Matles test performed with the patient under anesthesia) were close to reaching statistical significance when compared with palpation of the gap in the tendon with the patient awake ($P = 0.058$). Whichever tests were performed, at least two of them were positive for a subcutaneous tear of the Achilles tendon in all patients in this study.

Patients Without Achilles Tendon Tears

In the 28 patients in whom there was an injury to the posterior aspect of the leg but no Achilles tendon tear (age, 41.8 years; SD, 15.7), only palpation, calf squeeze, and Matles tests were performed (Table 3). In all cases, a gap was not detectable by palpation, and the calf squeeze test indicated that the tendon was intact. The Matles test, on the other hand, indicated a tear in two patients. In all cases, however, the tests showed a high capability to detect that the Achilles tendon was intact.

TABLE 3
Results of the Tests in 28 Patients with No Achilles Tendon Tear

Test	Positive[a]	Negative[b]	Dubious	Specificity	Negative predictive value
Gap	0	25	3	0.89	1
Calf squeeze	0	26	2	0.93	1
Matles	2	24	4	0.85	0.92

[a] Rupture diagnosed.
[b] No rupture diagnosed.

Patients Undergoing Closed Management or Percutaneous Repair

As no objective evidence of a subcutaneous tear of the Achilles tendon was obtained in patients who underwent closed management or percutaneous repair, I did not calculate sensitivity, specificity, and predictive values of the various tests. However, given the high sensitivity, specificity, and predictive values of all the tests used in this study, and the fact that a subcutaneous Achilles tendon tear was consistently found in the patients undergoing open repair when at least two of the clinical tests used in this study indicated it, it may be deduced that such patients did suffer from the condition, and were correctly managed.

DISCUSSION

Even though the condition was described more than 300 years ago, the diagnosis of subcutaneous Achilles tendon tear still poses difficulties.[15] While typical cases occur, the fact that so many tests have been devised to test the integrity of the Achilles tendon bears witness to the fact that diagnostic confusion is still relatively frequent. Although the first of these tests, the calf squeeze test, was described nearly 4 decades ago, all tests have been reported in studies with a relatively small number of patients.[18] For example, Simmonds[18] and Matles[13] described the test but did not report on patients, Thompson[19] and Thompson and Doherty[20] studied 22 patients, O'Brien[14] studied 10 patients and dissected 16 cadavers to find an anatomic explanation for the needle test he described, and Copeland[5] studied 20 patients before and 8 patients after treatment had ended. Also, there can be some confusion in the nomenclature of the tests. For example, the calf squeeze test was described in 1957 by Simmonds[18] in the U.K., and 5 years later by Thompson[19] and Thompson and Doherty[20] in the U.S. It is therefore known by two different names on the two sides of the Atlantic Ocean, Simmonds' test and Thompson test, respectively.[10]

To the best of my knowledge, no study has analyzed statistically the results of the application of the various tests in a large, unselected patient population. Ideally, in this study all tests should have been performed in all patients. However, the O'Brien and the Copeland tests were described only after the present study was begun. The O'Brien test was deemed painful with the patient awake, and invasive; therefore, I elected not to perform the test routinely after the first few patients were tested. When applying the Copeland test to awake patients, they complained of some discomfort, and I therefore decided to limit its use to patients who were totally cooperative.

Although, for the purposes of this study, it was shown that the sensitivity of some of the tests increased when they were performed with the patient under anesthesia (Table 1), the difference was not statistically significant, and I doubt whether it would be clinically relevant. An accurate diagnosis may be obtained with the patient fully awake.

A possible drawback of this study is that patients were seen within 4 weeks of the injury. In patients seen more than 4 weeks after injury, it is possible that the hematoma produced by the tendon tear has organized and reconstituted some continuity in the tendon. In these patients, the calf squeeze test can falsely indicate that there is no tear.[20] However, in such cases the partial reconstitution of continuity will have resulted in the tendon being longer than normal. In these patients, therefore, the Matles test should still be indicative of a tear. If the diagnosis is doubtful, the application of the other clinical tests is warranted, and an ultrasound or an MRI scan should be considered.

The main finding of this study is that all the tests described in the literature may be used to correctly diagnose a subcutaneous Achilles tendon tear with a high degree of certainty. Also, the tests may be used to correctly determine that the Achilles tendon is not torn. The results of the present study show that when two or more of these tests indicate a subcutaneous Achilles tendon tear, the diagnosis is certain. As palpation may be unreliable, and the Copeland and the O'Brien tests may cause discomfort when patients are awake, the tests routinely used in my clinical practice are the calf squeeze test and the Matles test.

The findings of this study should be applied to patients with relatively recent tears of their Achilles tendons. These findings should provide a baseline to be able to clinically diagnose an Achilles tendon tear with confidence. Given the present constraints on health care expenditures, and the litigious medicolegal environment, the necessity to reach a correct, rapid, and economical diagnosis is paramount.

In conclusion, the diagnosis of a subcutaneous tear of the Achilles tendon may be reliably made on the basis of the results of the calf squeeze and Matles tests, two simple and inexpensive clinical tests.

REFERENCES

1. Altman DG: *Practical Statistics for Medical Research.* London, Chapman and Hall, 1991, pp 258–259,
2. Altman DG, Bland JM: Diagnostic tests 1: Sensitivity and specificity. *BMJ 308:* 1552, 1994
3. Altman DG, Bland JM: Diagnostic tests 2: Predictive values. *BMJ 309:* 102, 1994
4. Arner O, Lindholm A, Lindvall N: Subcutaneous rupture of the Achilles tendon. A new roentgendiagnostic method. *Acta Chir Scand 119:* 523–525, 1960
5. Copeland SA: Rupture of the Achilles tendon: A new clinical test. *Ann R Coll Surg Engl 72:* 270–271, 1990
6. Daffner RH, Riemer BL, Lupetin AR, et al: Magnetic resonance imaging in acute tendon ruptures. *Skeletal Radiol 15:* 619–621, 1986
7. Józsa L, Kvist M, Bálint BJ, et al: The role of recreational sport activity in Achilles tendon rupture. A clinical, pathoanatomical, and sociological study of 292 cases. *Am J Sports Med 17:* 338–343, 1989
8. Keene JS, Lash EG, Fisher DR, et al: Magnetic resonance imaging of Achilles tendon ruptures. *Am J Sports Med 17:* 333–337, 1989
9. Ma GWC, Griffith TG: Percutaneous repair of acute closed rupture of Achilles tendon. A new technique. *Clin Orthop 128:* 247–255, 1977
10. Maffulli N: Clinical tests in sports medicine: More on Achilles tendon. *Br J Sports Med 30:* 250, 1996
11. Maffulli N, Dymond NP, Capasso G: Ultrasonographic findings in subcutaneous rupture of Achilles tendon. *J Sports Med Phys Fitness 29:* 365–368, 1989
12. Maffulli N, Dymond NP, Regine R: Surgical repair of ruptured Achilles tendon in sportsmen and sedentary patients: A longitudinal ultrasound assessment. *Int J Sports Med 11:* 78–84, 1990
13. Matles AL: Rupture of the tendo Achilles. Another diagnostic sign. *Bull Hosp Joint Dis 36:* 48–51, 1975
14. O'Brien T: The needle test for complete rupture of the Achilles tendon. *J Bone Joint Surg 66A:* 1099–1101, 1984
15. Paré A: *Les Ouevres.* Ninth edition. Lyon, Claude rigaud et Claude Obert, 1633
16. Rowley DI, Scotland TR: Rupture of the Achilles tendon treated by a simple operative procedure. *Injury 14:* 252–254, 1982
17. Scheller AD, Kasser JR, Quigley TB: Tendon injuries about the ankle. *Orthop Clin North Am 11:* 801–811, 1980
18. Simmonds FA: The diagnosis of the ruptured Achilles tendon. *The Practitioner 179:* 56–58, 1957
19. Thompson TC: A test for rupture of the tendo Achillis. *Acta Orthop Scand 32:* 461–465, 1962
20. Thompson TC, Doherty JC: Spontaneous rupture of Achilles: A new clinical diagnostic test. *J Trauma 2:* 126–129, 1962