The Achilles Tendon Total Rupture Score (ATRS) 
Development and Validation 

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Background: There is a need for a patient-relevant instrument to evaluate outcome after treatment in patients with a total Achilles tendon rupture. 

Purpose: To develop and validate a new patient-reported instrument for measuring outcome after treatment for total Achilles tendon rupture. 

Study Design: Cohort study (diagnosis); Level of evidence, 1. 

Methods: Development of this instrument consisted of item generation and test construction, item reduction, validation, evaluation of structure and internal consistency, test–retest, and test for responsiveness. The final version, the Achilles tendon Total Rupture Score (ATRS), was tested for validity, structure, and internal consistency (Cronbach’s alpha) on 82 patients and 52 healthy persons. A correlation analysis was performed of the ATRS with the 2 validated foot/ankle/Achilles tendon scores, the Foot and Ankle Outcome Score (FAOS) and the Swedish version of the Victorian Institute of Sports Assessment–Achilles questionnaire (VISA-A-S). Structure was evaluated with factor analysis. Test–retest reliability was validated on 43 patients. The ATRS responsiveness was tested on 43 patients by calculating the effect size. 

Results: The total score for the patients ranged from 17 to 100 with a mean (median) of 77 (85) and a standard deviation (interquartile range) of 21.4 (23). A significantly (P < .0001) higher total score was found for the healthy subjects, ranging from 94 to 100 with a mean (median) of 99.8 (100) and a standard deviation (interquartile range) of 1.1 (0). The ATRS correlated significantly (P < .01) with all subscales of the FAOS (r = 0.60-0.84) and the VISA-A-S (r = 0.78). The factor analysis gave 1 factor of importance. The internal consistency was 0.96 as measured with Cronbach’s alpha. The test–retest produced an intraclass correlation coefficient of 0.98. The tests for responsiveness showed an effect size between 0.87 and 2.21. 

Conclusion: The ATRS is a patient-reported instrument with high reliability, validity, and sensitivity for measuring outcome after treatment in patients with a total Achilles tendon rupture. 

Clinical Relevance: The ATRS is a self-administered instrument with high clinical utility, and we suggest the score for measuring the outcome, related to symptoms and physical activity, after treatment in patients with a total Achilles tendon rupture. 

Keywords: Achilles tendon; rupture; score; outcome 

The Achilles tendon is the most frequently ruptured tendon, and ruptures usually occur in middle-aged men during sporting activity.7,17 The incidence of these ruptures has increased during the past few decades.7,12,15,17,18 The treatment is still controversial, and the main alternatives are either surgical or nonsurgical.2,3,5,9,10,13,17,20,29 During the past decade, surgical treatment has been regarded as the first choice in many hospitals. In addition, it has become common to add early functional mobilization, such as using an adjustable brace, after surgical treatment.4,13,14,15,34 Studies on treatment with only early functional mobilization, using a mobile cast without any preceding surgery, also show promising results.16,25 It has been shown that the incidence of rerupture is higher in nonsurgically treated patients, but the risk varies between different studies.2,3,8,9,16,19,20 Surgically treated patients have,
however, an increased risk of complications such as infections and wound problems.\textsuperscript{2,10,21}

It has become more frequent to use patient-reported outcome scores to evaluate functional results and to compare incapacity on an individual level.\textsuperscript{31} Validated scores are found for the shoulder (the Western Ontario Rotator Cuff index),\textsuperscript{11} the knee (the Knee Injury and Osteoarthritis Outcome Score),\textsuperscript{24} and the ankle (the Foot and Ankle Outcome Score [FAOS]).\textsuperscript{25} Furthermore, there are scores for patients with patellar tendon injuries (the Victorian Institute of Sports Assessment [VISA] questionnaire, an index of severity of symptoms in patients with jumper's knee, patellar tendinopathy),\textsuperscript{26} and Achilles tendinopathy (the VISA-A questionnaire, an index of clinical severity for patients with Achilles tendinopathy).\textsuperscript{27} There is also, however, a need for an easily self-administered, validated, and sensitive instrument with high reliability that evaluates symptoms and their effect on physical activity in patients with Achilles tendon rupture. An instrument is needed that can be used to compare different patient populations, evaluate the outcome of treatment, facilitate comparisons between studies, determine the patient's clinical severity, provide a guideline for treatment, and monitor treatment effects.\textsuperscript{28} Outcome measures found in the literature for patients with an Achilles tendon rupture are nonvalidated and are based on a mixture of assessments of subjective and objective parameters.\textsuperscript{12,16,19,22,29,33}

The purpose of this study is to develop and validate a new patient-reported instrument for measuring outcome, related to symptoms and physical activity, after treatment for total Achilles tendon rupture.

MATERIALS AND METHODS

The development of this new instrument consisted of 5 steps, as described in Figure 1. A total of 167 male and female patients (Table 1) with a total Achilles tendon rupture participated in the study. Twenty-seven of these patients were included twice in the various steps. The human research ethics committee at the Faculty of Medicine, Göteborg University, Sweden, approved the study. Written informed consent was obtained, and the rights of subjects were protected.

The inclusion criteria were as follows:

- Total Achilles tendon rupture based on a clinical examination, performed by an orthopaedic surgeon
- Age of 20 to 70 years
- Ability to read and understand the Swedish language

Step 1: Item Generation and Test Construction

The development of this instrument started with a literature survey. No validated score related to symptoms and to physical activity was found in the literature for patients with a total Achilles tendon rupture to assess the subjective functional outcome. However, Robinson et al\textsuperscript{23} developed a questionnaire as an index of clinical severity in patients with chronic Achilles tendinopathy: the VISA-A. The VISA-A questionnaire evaluates symptoms and their effect on physical activity and can be used to compare different populations with Achilles tendinopathy and facilitate comparisons between studies. A validated score was found for patients with ankle ligament injuries: the FAOS.\textsuperscript{25} The FAOS includes 42 questions with 5 separate subscales: Pain, Other Symptoms, Activities of Daily Living, Sport and Recreation Function, and Foot- and Ankle-Related Quality of Life.

An expert group, consisting of 4 orthopaedic surgeons and 4 physical therapists, all with several years of experience with this patient group, participated in this study. The face validity of the items in the VISA-A-S\textsuperscript{26} (the Swedish version of the VISA-A\textsuperscript{1}) questionnaire and the FAOS was discussed,
Twenty-seven patients were included in more than 1 step. The field of whether the instrument samples relevant content of the structure of the ATRS. Formed consisting of 14 items with the highest face validity. The new instrument was named the Achilles tendon Total Rupture Score. The aim was to establish good content validity, defined as a subjective judgment by experts in the field of whether the instrument samples relevant content or domains.27

Step 2: Item Reduction

The ATRS was sent to 100 patients with a total Achilles tendon rupture, selected from a database of patients treated at the Sahlgrenska University Hospital, Göteborg, Sweden. To increase the number of patients treated nonsurgically, an additional 27 patients were included from ongoing studies. Patients were included if they had had their injury for a minimum of 3 months and a maximum of 3 years. The patients were asked to respond to the 14 items, reflecting symptoms and physical activities, using an 11-grade Likert-scale. The scale ranged from 0 = major limitations/symptoms to 10 = no limitations/symptoms. There were associated labels for 0 and 10 but not for the intermediate numbers.

The subjects were encouraged to comment freely on the items. It was decided that 2 missing values did not influence the results. If more than 2 values were missing, the test was considered invalid. Data were missing for 2 questions in 2 patients. In these cases missing data were calculated as zero, because these patients were 3 months postinjury. This procedure did not influence the results.

In total, 112 (88%) of the 127 patients completed the ATRS. An item analysis was performed to evaluate each item. In addition, a factor analysis was applied to evaluate the structure of the ATRS.

Considering the results and comments from the patients, we excluded 4 items. The following items were excluded:

- Item reduction (patients n = 112, 21 f + 91 m)
- Evaluation of the final ATRS (patients n = 82, 19 f + 63 m)
- Healthy subjects (healthy n = 52, 19 f + 33 m)
- Test–retest of the ATRS (n = 43, 7 f + 36 m)
- Responsiveness of the ATRS (n = 43, 8 f + 36 m)

5 female; m, male; ATRS, Achilles tendon Total Rupture Score.

Step 3: Evaluation of the Final ATRS

The final version of the score was sent to 100 patients from the earlier described database and to 15 patients from ongoing studies. To test for construct validity, we examined the extent to which a measure correlates with measures of other variables in ways that can be explained theoretically.27 And sought to determine how closely the ATRS was related to other measures of the same construct to which it should be related, that is, to test for convergent validity.27 All subjects were asked to also complete the FAOS and the VISA-A-S questionnaire. In total, 82 (71%) of the 115 patients completed the final ATRS. Three of the 82 patients were excluded because they answered fewer than 8 questions, so the total sum score of 100 points was evaluated on 79 patients. Seventy-one (62%) of the 115 patients completed the final ATRS. Three of the 82 patients were excluded because they answered fewer than 8 questions, so the total sum score of 100 points was evaluated on 79 patients. Seventy-one (62%) of the 115 patients completed the final ATRS. Three of the 82 patients were excluded because they answered fewer than 8 questions, so the total sum score of 100 points was evaluated on 79 patients.

Step 4: Test–Retest of the ATRS

For evaluation of test-retest reliability, 43 patients completed the ATRS twice within 2 weeks.

Step 5: Responsiveness of the ATRS

As a measure of responsiveness, the effect size was calculated on the results from 43 patients at the 3- to 6-month follow-ups (15 patients) and at the 6- to 12-month follow-ups (28 patients).

Statistics

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 12.0 for Windows, SPSS Inc, Chicago, Ill). Standard procedures were used for descriptive statistics. All the correlation coefficients (r) were
calculated using Spearman’s rank correlation. Differences between patients and healthy subjects were evaluated with the Mann-Whitney U test. Internal consistency was calculated using Cronbach’s alpha. For test–retest evaluation we calculated the intraclass correlation coefficient, and to study differences within groups we calculated the Wilcoxon paired test. Significance was considered at the α level of $P < .05$. A maximum likelihood factor analysis using Harris Kaiser’s rotation method with an eigenvalue $> 1$ was applied to the ATRS. The effect size was calculated as the mean score difference divided by standard deviation from the initial measurement according to Kazis et al. An effect size of $> 0.80$ was considered high.

## RESULTS

The scores for the 10 items in the final version of the ATRS all ranged from 0 to 10. The mean (median) item score ranged from 6.2 (7.0) to 8.7 (10.0) with a standard deviation (interquartile range) of 3.3 (6.8) and 1.9 (2.0), respectively (Table 2). The total score for the patients ranged from 17 to 100, with a mean (median) of 77 (85) and an SD (interquartile range) of 21.4 (23). A significantly ($P < .0001$) higher total score was found for the healthy subjects, ranging from 94 to 100 with a mean (median) of 99.8 (100) and an SD (interquartile range) of 9.3 (4.5).

The ATRS correlated significantly ($P < .01$) with all subscales of the FAOS (Pain $r_s = 0.60$, Other Symptoms $r_s = 0.73$, Activities of Daily Living $r_s = 0.68$, Sport/Recreation Function $r_s = 0.84$, Foot- and Ankle-Related Quality of Life $r_s = 0.79$) and with the VISA-A-S questionnaire ($r_s = 0.78$). The factor analysis produced 1 factor of importance with an eigenvalue $> 1$, indicating that the items used in the final version of the ATRS reflect 1 dimension, related to symptoms and physical activity.

There was a significantly ($P < .03$) higher score on the second test day (mean 77.2, median 86) compared with the first test day (mean 80.0, median 84). The intraclass correlation coefficient was 0.98. The internal consistency of the final 10 items in ATRS was 0.96 as calculated with Cronbach’s alpha.

The effect size for the 3- to 6-month follow-ups was 2.21 and for the 6- to 12-month follow-ups was 0.87.

## DISCUSSION

This study presents a new score designed by the authors using patients and experts as a reference group. The patients were encouraged to comment freely on the first 14-item score. The procedure resulted in good face and content validity.

Both internal consistency and test–retest calculations were made to test the reliability of the instrument. The high internal consistency found in the present study clearly demonstrates that the instrument measures the same construct or dimension, that is, how patients were limited by their symptoms during various physical activities. The procedure used for test–retest evaluation resulted in high intraclass correlation coefficient values. A small significant difference of 2 to 3 points was noted between test days, indicating that the 2 weeks used between test days might have
been somewhat long. We believe that this difference is not clinically relevant.

In developing this new score we carefully followed the steps outlined by Suk et al.25 The score demonstrates good construct and convergent validity with high correlations with other validated instruments such as the FAOS26 and the VISA-A-S questionnaire26 and with healthy subjects scoring significantly higher than the patients. The same basic procedure was used to develop the ATRS as was used to develop the FAOS and the VISA-A-S questionnaire. The good convergent validity demonstrates that the ATRS measures similar aspects as measured in the various subscales of the FAOS. The FAOS consists of 42 items in 5 subscales and is an adaptation of the validated Knee injury and Osteoarthritis Outcome Score.24 The FAOS is self-administered but contains several questions that were considered to have low face validity for Achilles tendon total rupture patients. Furthermore, the clinical utility of the FAOS was considered to be lower in this group of patients and to require more time to complete and analyze than the new score presented in this study. Likewise, a correlation of $r_s = .78$ with the VISA-A-S questionnaire is relevant because the instrument measures pain, symptoms, and physical activity aspects among patients with chronic Achilles tendinopathy.23,26 The VISA-A-S questionnaire also contains questions that were considered to have low face validity for patients with Achilles tendon total rupture.

Criterion validity could not be established for the new score because no “gold standard” score exists for Achilles tendon total rupture.

The purpose of this study was to develop a score that reflects the patients’ opinions of restrictions caused by symptoms during various physical activities. The initial factor analysis on the 14-item scale resulted in 3 factors. After item analysis and item reduction, a 1-factor score reflecting the desired dimension of symptoms and physical activity was achieved. This score comprised 10 items and was used as the final version of the ATRS.

Acceptable response rates of 88% in step 2 (item reduction) and 71% in step 3 (evaluation of the final ATRS) were achieved. A reminder was sent to patients who did not answer the first letter, but no further responses were received. No separate analysis was performed on subjects who did not complete the scores, but the majority of nonresponders reported that they did not have the time to respond. There are thus no reasons to believe that the nonresponders differ in any significant way from the respondents.

In the literature, some nonvalidated scores are presented for patients who have total Achilles tendon rupture.12,16,19,30 The first 3 of these scores12,16,19 are based on the score presented by Thermann20 and are not self-administered but are partly clinician-based outcome measures. All these scores contain a mixture of items reflecting patient symptoms and range of motion and strength measurements. All these scores could potentially be reliable, valid, and sensitive, but these have not been tested for in previous studies. The new patient-reported outcome measure (ATRS) has high clinical utility being both patient and clinician friendly.25 The instrument can be completed in a couple of minutes, and the score from the 10 items is determined in less than a minute.

The questions are, according to comments from the patients in the study, clear, concise, and easy to understand. No patients reported being uncomfortable answering any of the questions. Furthermore, the score is self-administered and can be managed by any staff member after a minimum of training. The score can thus be an important complement to the arsenal of evaluation methods for prospective and randomized studies on patients with an Achilles tendon total rupture. It may be useful to compare different patient populations and facilitate comparisons between studies. In the clinic, the score can be used as a complement to assess the patient’s disability and provide a guideline for treatment as well as for monitoring the effect of treatment. We suggest that a 10-point difference is clinically relevant.

CONCLUSION

The ATRS is a patient-reported instrument with high reliability, validity, and sensitivity for measuring the outcome related to symptoms and physical activity after treatment in patients with a total Achilles tendon rupture. The ATRS is a self-administered instrument with high clinical utility.

ACKNOWLEDGMENT

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REFERENCES

APPENDIX

ATRS

(Achilles Tendon Total Rupture Score)

All questions refer to your limitations/difficulties related to your injured Achilles tendon.

Mark with an X in the box which matches your level of limitation!

1. Are you limited due to decreased strength in the calf/Achilles tendon/foot?

2. Are you limited due to fatigue in the calf/Achilles tendon/foot?

3. Are you limited due to stiffness in the calf/Achilles tendon/foot?

4. Are you limited due to pain in the calf/Achilles tendon/foot?

5. Are you limited during activities of daily living?

All questions refer to your limitations/difficulties related to your injured Achilles tendon.

Mark with an X in the box which matches your level of limitation!

6. Are you limited when walking on uneven surfaces?

7. Are you limited when walking quickly up the stairs or up a hill?

8. Are you limited during activities that include running?

9. Are you limited during activities that include jumping?

10. Are you limited in performing hard physical labor?

Total Score:

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Mark with an X in the box which matches your level of limitation!