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Defining Components of Early Functional Rehabilitation for Acute Achilles Tendon Rupture

A Systematic Review

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Investigation performed at Aalborg University Hospital, Aalborg, Denmark

Background: Early functional rehabilitation is frequently discussed in treating Achilles tendon rupture. A consistent definition of what constitutes early functional rehabilitation has not been established across the literature, despite studies supporting its efficacy. A standardized definition would be helpful to pool data across studies, allow for between-study comparisons, and ultimately work toward developing clinical guidelines.

Purpose: To define early functional rehabilitation (including when it is initiated and what it entails) when used to treat Achilles tendon rupture and to identify outcome measures for evaluating the effect of treatment.

Study Design: Systematic review; Level of evidence, 4.

Methods: Ovid MEDLINE, EMBASE, PEDro, CINAHL, and Cochrane databases were searched for relevant studies. Eligibility criteria for selecting studies consisted of randomized controlled trials, cohort studies, and case series (≥ 10 participants) including weightbearing or exercise-based interventions within 8 weeks after Achilles tendon rupture.

Results: A total of 174 studies published between 1979 and 2018 were included. Studies were rated a median (interquartile range [IQR]) of 17 (15-20) on the Downs & Black checklist and included 9098 participants. Early functional rehabilitation incorporated weightbearing (95%), range of motion (73%), and isometric/strengthening exercises (50%). Weightbearing was initiated within the first week, whereas exercise (eg, ankle range of motion, strengthening, whole-body conditioning) was initiated in the second week. Initiation of exercises varied based on whether treatment was nonsurgical (mean, 3.0 weeks; IQR, 2.0-4.0 weeks) or simple (mean, 2.0 weeks; IQR, 0.0-2.3 weeks) or augmented surgical repair (mean, 0.5 weeks; IQR, 0.0-2.8 weeks) ($P = .017$). Functional outcomes including ankle range of motion ($n = 84$) and strength ($n = 76$) were reported in 130 studies. Other outcome domains included patient-reported outcomes ($n = 89$), survey-based functional outcomes ($n = 50$), and tendon properties ($n = 53$).

Conclusion: Early functional rehabilitation includes weightbearing and a variety of exercise-based interventions initiated within the first 2 weeks after acute Achilles tendon rupture/repair. Because early functional rehabilitation has lacked a standardized definition, interventions and outcome measures are highly variable, and pooling data across studies should be done with attention paid to what was included in the intervention and how treatment was assessed.

Keywords: Achilles; mobilization; weightbearing; ankle; outcomes

The yearly incidence of Achilles tendon rupture is up to 37 per 100,000 individuals.^{61,105,160} There is ongoing debate regarding optimal treatment, as attention has shifted away from outcomes such as rerupture rates and toward function-based outcomes.⁷⁴ Plantar flexor weakness^{22,72,103} and biomechanical asymmetries with running and jumping activities^{23,200} persist in the long term. These may limit

performance capacity or predispose these individuals to other orthopaedic conditions such as patellofemoral joint pain.²⁰⁰ It is important that patients recover within the first year after injury, as 1-year outcomes predict whether individuals will be left with long-term disabilities.^{23,69}

Early functional rehabilitation has become a buzz phrase in treating Achilles tendon rupture. A consistent definition of what constitutes early functional rehabilitation has not been established across the literature, despite studies identifying that early functional rehabilitation was safe, resulted in higher patient satisfaction, improved function,

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and led to faster return to work and sport in some instances.^{24,67,99,117,193} Systematic reviews have supported the use of early functional rehabilitation to optimize patient outcomes regardless of whether a participant is managed nonsurgically⁵⁵ or surgically.^{21,24,78,128} A standardized definition would be helpful to pool data across studies, allow for between-study comparison, and ultimately work toward developing clinical guidelines.

The components in defining early functional rehabilitation include establishing what types of treatment recommendations comprise early functional rehabilitation and when they are initiated. Prior systematic reviews investigating the efficacy of early functional rehabilitation^{21,24,55,78,128} have provided limited guidance as to the working definition of this term, relying on author-delineated, inconsistent definitions of *early*. For example, Brumann et al²⁴ limited studies to those including weightbearing or ankle mobilization in the first 3 weeks, McCormack and Bovard¹²⁸ included only studies that included any type of rehabilitation by 2 weeks, and El-Akkawi et al⁵⁵ limited study inclusion to those that initiated rehabilitation by 4 weeks. Variations between systematic review–level evidence point to the lack of uniform definition of early functional rehabilitation.

The standardization of outcomes used to assess patient response to intervention is another critical piece in understanding the effectiveness of early functional rehabilitation. As part of the Core Outcome Measures in Effectiveness Trials (COMET) Initiative, core outcome sets are being developed and applied in an effort to improve direct comparisons across studies.¹⁹⁸ This is in response to the challenge of pooling literature with large variability in reported outcomes¹³ as well as substantial problems with missing data for primary outcomes.¹⁹⁸ A first step in the development of a core outcome set is to identify the outcome measures used in clinical trials. A core outcome set is being discussed for Achilles tendinopathy^{114,176}; however, to date, an Achilles tendon rupture–specific set has not been initiated in the literature.

The purpose of this study was to comprehensively define early functional rehabilitation in terms of what types of interventions are delivered to patients with Achilles tendon rupture and when. We hypothesized that treatment was initiated earlier in more recent studies, so we investigated changes in trends of early functional rehabilitation onset over time. Secondly, we sought to identify the outcome measures that have been used to assess patient response to

these rehabilitative protocols as a first step in identifying a core outcome set for this patient population.

METHODS

This study was a systematic review of the literature on early functional rehabilitation for Achilles tendon rupture. The study was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and was registered on the Prospero database (registration ID: CRD42017062300). Due to the size of the study, we are reporting results for the definition of early functional rehabilitation portion of the Prospero protocol, and work regarding specific rehabilitation protocols is ongoing. The search was completed on May 9, 2018.

Search Strategy

The search strategy was based on the PICO (Patient, Intervention, Comparator, and Outcome) model. Development of the search string and conduct of the search were done with the assistance of a research librarian. The complete search string is included in Appendix Table A1. Databases included in the search were Ovid MEDLINE, EMBASE, PEDro, CINAHL, and the Cochrane Database.

Study Inclusion and Exclusion

For the purposes of this review, we broadly defined early functional rehabilitation as having weightbearing and/or ankle-focused exercises beginning within the first 8 weeks and while the patient is still using an immobilization device (ie, orthosis, cast, specialized treatment boot). In the event that no immobilization device was used during the course of treatment, early functional rehabilitation was defined as weightbearing and exercises started within the first 8 weeks after injury or surgery.

Included studies needed to involve patients at least 18 years of age treated with early functional rehabilitation after acute (defined as treated within 2 weeks) Achilles tendon rupture. Studies needed to be randomized controlled trials (RCTs), cohort studies, or case series with a minimum of 10 participants. Narrative reviews, systematic reviews and meta-analyses, and case studies were excluded. Studies were excluded if participants with diabetes, neurological conditions, or only chronic or delayed treatment were included. In studies including participants

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with acute and delayed ruptures, only data pertaining to the acute rupture group were included in the review. Due to the limitations of languages spoken by the investigatory team and access to translators, only studies in English, Danish, Swedish, Norwegian, German, French, Spanish, or Portuguese were included.

Data Extraction: Defining Early Functional Rehabilitation

Study inclusion and exclusion were determined by 2 independent reviewers (J.A.Z., M.C.) using Covidence systematic review software (Veritas Health Innovation) for citation management. In the event that consensus regarding inclusion could not be met, a third reviewer was consulted (K.G.S.). Data extraction was completed by 2 independent reviewers (J.A.Z., M.C.) using a REDCap database,⁷⁰ with the exception of non-English studies. Disagreements between reviewers were resolved through discussion, and if consensus could not be met, a third reviewer was consulted (K.G.S.). For non-English studies, a single reviewer completed data extraction due to language comprehension constraints among the study team.

Data extraction included study design (RCT, cohort study, or case series), number of participants, treatment type (surgical, nonsurgical, or both), and, when applicable, surgery type (simple repair or augmented repair). Type of early functional rehabilitation was categorized as follows: weightbearing, range of motion (exercises or as allowed by an orthosis permitting some movement), strength exercise with resistance and progression, isometric exercise, cardiovascular-based exercise (eg, stationary bike), general and core strengthening, balance, and other. All rehabilitation strategies used during the first 8 weeks and while participants were still using some form of immobilization were included. Timing of exercise and weightbearing onset was recorded. In cases where 2 or more groups with different rehabilitative protocols were used, the content of these protocols was combined for the purposes of describing type of rehabilitation, and the earliest onset time across groups was recorded.

Methodological Quality Assessment

Studies were assessed for methodological quality through use of the modified Downs & Black^{79,98,145} checklist, in which 26 or above indicates excellent, 20-25 good, 15-19 fair, and 14 or less poor quality. Studies in English were scored by 2 independent reviewers. If there were inconsistencies in reviewer response, a third reviewer (J.A.Z. or M.C.) was consulted. Similar to data extraction, non-English language studies were scored by a single reviewer.

Data Extraction: Outcome Measures Data

Outcome measures used in each study were noted and subgrouped by domain (patient-reported outcome, survey-based functional outcome, functional outcome, and tendon properties). Time of outcomes assessment was recorded as 0-3 months, 4-6 months, 7-12 months, >1-5 years, and >5

years. All time points were extracted. If a study did not have predetermined time points for assessment, the mean or median time of assessment was recorded.

In cases where 2 or more studies analyzed the same group of participants, the studies were combined for the purposes of extracting outcome types and timing of outcomes assessment, and the primary study was used for total number of participants, rehabilitation strategy, and quality assessment. This was done to maximize the number of outcomes reported while not artificially inflating participant numbers.

Data Analysis

Data failed the assumptions of parametric statistics based on the Shapiro-Wilk test, so nonparametric tests were used for analysis. Descriptive statistics used are frequencies, medians, and interquartile ranges (IQRs). To better understand the types of studies included in this review, the relationship of study publication year and study quality was assessed by Spearman correlation.

To investigate timing of early functional rehabilitation, the onset of weightbearing and exercise (in weeks, with 0 indicating days 0-6, 1 indicating days 7-13, etc) is reported as frequencies of studies using a given start time. Time of weightbearing and exercise onset was also investigated by treatment intervention subgroup (nonsurgical, simple repair, or augmented repair), and differences in time of onset were compared between groups through use of an independent-samples Kruskal-Wallis test. Studies investigating only 1 type of treatment were included in the subgroup analysis. This is because it is possible that information from both treatment groups would have been listed together in studies comparing 2 different initial treatment strategies.

To identify changes in early functional rehabilitation over time, time of weightbearing and exercise onset was compared with publication year by use of Spearman correlation. Because not all studies included in the review were included in the individual analyses (eg, a study involving only early exercise would not be included in the weightbearing analyses), for each analysis the total number of primary studies included along with their median Downs & Black checklist score is reported.

RESULTS

Search Results and Study Inclusion

The results of the search and study inclusion are shown in Figure 1. Of the 174 included studies, 157 studies[#] were found to be primary studies, and 17 studies^{**} were found to have overlapping populations and were included only in the reporting of additional outcomes and outcome

[#]References 1-12, 14, 16-18, 25-28, 30-36, 38-40, 42-46, 48, 50-54, 57, 58, 60, 62-68, 72, 73, 75-77, 80-86, 88-97, 99-103, 106-113, 115-117, 119-127, 129, 131-134, 137-144, 146, 150-159, 161-175, 179-187, 189-196, 199, 201-204.

^{**}References 15, 19, 20, 41, 47, 71, 87, 104, 118, 130, 135, 136, 147-149, 188, 197.

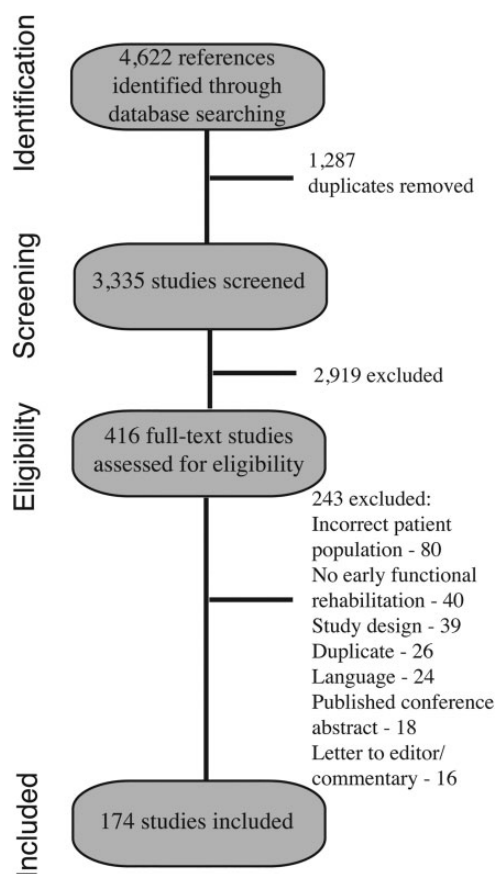


Figure 1. Search results and study inclusion-exclusion flowchart.

assessment timeframes. We included 16 non-English studies: 12 in German, 2 in Portuguese, 1 in Danish, and 1 in Spanish (see Appendix Tables A2 and A3).

Descriptive Analysis of Included Studies

Included primary studies were published between 1979 and 2018 (median [IQR], 2010 [2002-2015]), consisting of 38 RCTs and 119 cohort studies or case series. Studies rated a median [IQR] (range) of 17 [15-20] (4-25) on the Downs & Black checklist for quality assessment (see Appendix Table A2).

Included studies had a median [IQR] (range) of 40 [25-66] (10-363) participants, with a total of 9098 participants included in this systematic review. The included RCTs contained significantly more participants versus the cohort studies (median [IQR], range: RCTs, 52 [39-74], 14-156; cohort/case series, 35 [22-66], 10-363; $P = .011$) (Figure 2). Participants were managed surgically in 112 studies and nonsurgically in 20 studies (see Appendix Tables A2 and A3). A total of 24 studies included both surgical and nonsurgical groups, and 1 study had treatment described as “other” (open fibrin gluing without end-to-end repair). Surgery type was a simple repair in 114 studies and augmented repair in 33 studies.

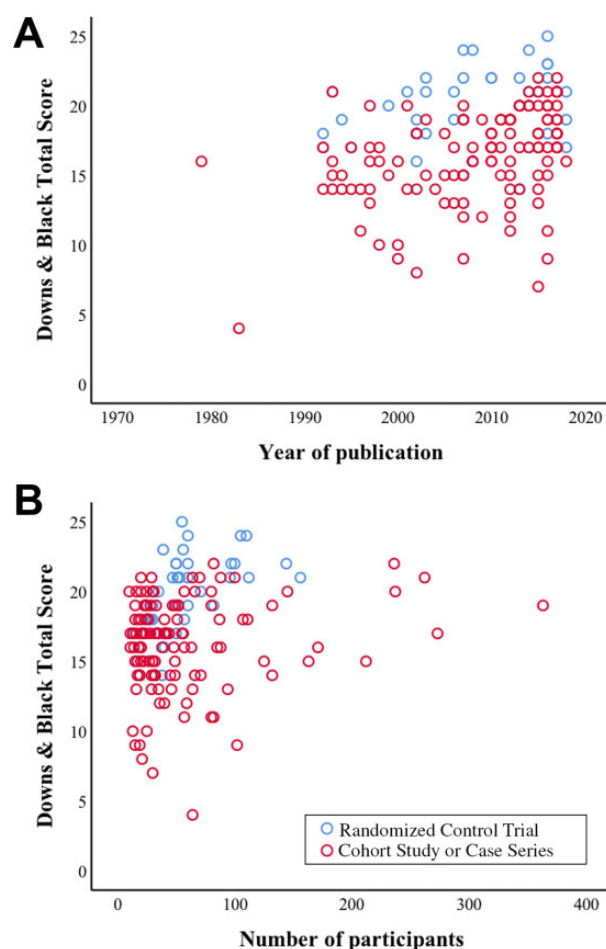


Figure 2. (A) Year of publication positively relates to study quality. (B) Distribution of number of participants to study quality by study design.

Onset of weightbearing was a median [IQR] of 2 weeks [0-3 weeks] after injury (Figure 3). Onset of exercise was a median (IQR) of 2 weeks (0-3 weeks) after injury (Figure 3).

Type of Early Functional Rehabilitation

Type of early functional rehabilitation is depicted in Figure 4. Interventions that were categorized as “other” (number of studies in parentheses) included massage (8), stretching (8), proprioception (8), electrical stimulation (5), cryotherapy (4), coordination (3), aqua therapy (3), proprioceptive neuromuscular facilitation (2), joint mobilization (1), ankle self-mobilization (1), neuromuscular exercise (1), night splint (1), and laser (1).

Descriptive Analysis of Early Functional Rehabilitation Onset by Treatment Subgroup

Distribution of the timing of weightbearing onset was not significantly different between groups (median [IQR]

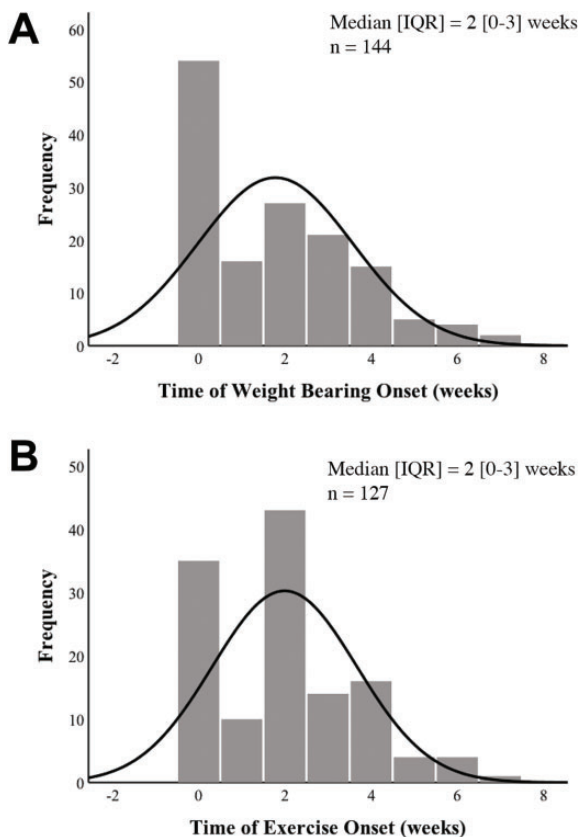


Figure 3. (A) Timing of weightbearing onset in entire group. (B) Timing of exercise onset in entire group.

nonsurgical, 0.0 [0.0-2.0]; simple surgical, 1.0 [0.0-3.0]; augmented surgical, 2.5 [0.0-3.0] weeks; $P = .060$) (Figure 5). Distribution of the timing of exercise onset was significantly different between groups (median [IQR] nonsurgical, 3.0 [2.0-4.0]; simple surgical, 2.0 [0.0-2.3]; augmented surgical, 0.5 [0.0-2.8 weeks]; $P = .017$) (Figure 5).

No differences were found in year of publication ($P = .530$) or study quality ($P = .148$) between studies based on initial intervention (nonsurgery, primary repair, or augmented repair) (nonsurgery: $n = 20$, median [IQR] year of publication = 2008 [1998-2016], study quality = 17 [14-20]; primary repair: $n = 82$, year of publication = 2011 [2003-2015], study quality = 17 [15-19]; augmented repair: $n = 20$, year of publication = 2007 [2001-2012], study quality = 15 [13-18]).

Change in Study Quality Over Time

Study quality improved with year of publication ($r_{sp} = 0.33$; $P < .001$) (Figure 2). In studies where exercise was initiated within the first 8 weeks ($n = 127$) (Downs & Black checklist score median [IQR], 17 [15-20]), time of exercise onset significantly increased with year of publication ($r_{sp} = 0.198$; $P = .026$) but was not significantly related to study quality ($r_{sp} = -0.016$; $P = .862$). In studies where weightbearing was initiated within the first 8 weeks ($n = 144$, Downs &

Black checklist score median [IQR], 18 [15-20]), time of weightbearing onset was not significantly related to year of publication ($r_{sp} = -0.079$; $P = .344$) or study quality ($r_{sp} = 0.047$; $P = .572$).

Outcome Measures

Common outcome measures are shown in Figure 4 and Table 1. General outcomes categorized as “other” (number of studies in parentheses) in multiple studies included satisfaction (40), pain (29), time to a selected milestone (12), metrics regarding hospital stay or length (9), operative time (8), number of office or physical therapy visits (5), footwear restrictions (5), cost (4), Thompson/Matles test (4), Achilles tendon resting angle (3), Hannover scale (3), Boyden scale (3), aesthetics of surgical site (4), scale devised by the authors (2), Achilles tendon repair score (2), and pain medication use (2). A total of 4 studies included general “other” outcomes that were not used in any other study.

For the patient-reported outcomes domain, outcomes categorized as “other” in multiple studies included self-rating of specified functional activity (8), Victorian Institute of Sport Assessment – Achilles questionnaire (VISA-A) (6), EuroQol-5D (4), RAND 36-Item Health Survey (RAND-36) (3), Grimby Physical Activity Scale (4), Tegner Scale (3), Functional Index for Lower Leg (2), and 12-Item Short Form Health Survey (SF-12) (2). There were 9 studies that included outcomes not used by any other study.

For the functional outcomes domain, outcomes categorized as “other” in multiple studies included jump or hop testing (15), heel-toe walking (12), ankle circumference (4), pedobarography (3), ankle passive stiffness (3), muscle activity or electromyography (3), single-legged balance (3), and quadriceps circumference (2). For tendon-level outcomes, 2 studies reported other outcomes not used in any other study. Tendon-level outcomes categorized as “other” in multiple studies included tendon appearance on ultrasonography (11), tendon appearance on magnetic resonance imaging (7), tendon mechanical properties (7), gap distance (4), tendon adhesions (4), and muscle appearance on diagnostic imaging (3). We found that 7 studies reported outcomes that were not used in any other study.

Study outcomes were assessed between 0 and 3 months in 52 studies, between 4 and 6 months in 58 studies, between 7 and 12 months in 60 studies, between 1 and 5 years in 75 studies, and longer than 5 years in 8 studies (see Appendix Table A3).

DISCUSSION

This systematic review is the first to comprehensively evaluate the available literature to define early functional rehabilitation after Achilles tendon rupture with regard to type and timing of rehabilitative treatment. Early functional rehabilitation in the treatment of Achilles tendon rupture is commonly used (>150 publications) but still lacks a consistent definition. Lack of standardization of content and timing when this intervention is initiated hampers

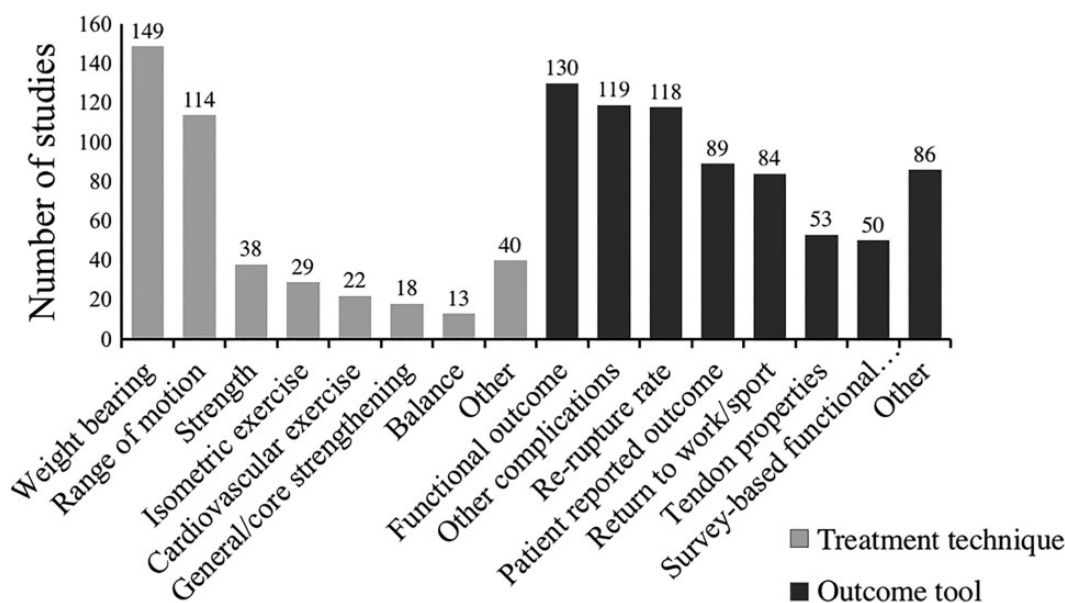


Figure 4. Type of early functional rehabilitation and outcome measures used.

evidence synthesis and implementation into clinical practice. Based on our comprehensive overview of the available literature, we define early functional rehabilitation as starting in the first 2 weeks after an acute Achilles tendon rupture. Such rehabilitation consists of a variety of weight-bearing and exercise-based interventions.

Early functional rehabilitation tends to begin within the first 2 weeks after injury or surgery; however, there are subtleties in timing of weightbearing and exercise components based on initial treatment strategy (Figure 3). After surgical repair, both weightbearing and exercises tend to begin simultaneously—either immediately or 2 weeks after surgical repair. With nonsurgical management, the tendency is to initiate weightbearing immediately but delay initiation of exercise. Differences in trends of exercise onset between surgically and nonsurgically managed participants may result from clinical decision making aimed at approximating the tendon ends³⁷ and avoiding complications^{29,49} while simultaneously providing enough tensile load to promote tendon healing.^{59,174}

Early functional rehabilitation protocols incorporated a variety of different exercise-based intervention. Ankle range of motion was the most commonly included intervention. The goal of range of motion is likely to assist in tendon gliding and to prevent deep adhesion. In the context of this study, range of motion included both traditional ankle range of motion outside of the orthosis and use of a hinged orthosis. After ankle range of motion, strengthening was the next most common intervention. Despite mechanistic studies supporting the role of gradual tensile loading in order to promote tendon recovery,^{6,59,174} only 52% (66/127) of studies with exercise-based interventions included isometric or other strengthening exercise. Less frequently did exercise interventions address more holistic concerns such as cardiovascular and global strengthening.

Timing of rehabilitation onset did not decrease relative to study year as we had hypothesized. Exercises were started later in more recent studies, and no relationship was observed between publication year and weightbearing onset. These findings could be explained by our inclusion criteria. A higher number of studies from more recent years were included, which may reflect more studies initiating rehabilitation within the first 8 weeks and when participants were still using an orthosis. Studies published less recently may have been excluded, skewing relationships between publication year and timing of rehabilitation onset.

A variety of outcome measures are used to assess patient response to treatment after Achilles tendon rupture. Broadly, these measures can be described in 2 groups: population-specific outcomes and general outcomes. Specific to this patient population, a variety of functional measures are commonly used along with tendon morphology and diagnosis-specific outcome measures, such as the Achilles tendon Total Rupture Score (ATRS). When looking at general outcomes, the American Orthopedic Foot and Ankle Score (AOFAS) was used in several studies as were numerous other patient-reported outcomes, such as patient satisfaction. From a research standpoint, it would be beneficial to develop a core outcome set that uses a combination of general and population-specific measures to allow comparison between populations of individuals with varying diagnoses as well as measures that more comprehensively assess the concerns of this particular patient population. The data from this study can be used as a first step in developing a core outcome set, as we have compiled frequencies of commonly used outcomes across multiple domains of patient assessment.

The available literature poses a variety of challenges regarding early functional rehabilitation after Achilles tendon rupture. Looking across the included literature, we find

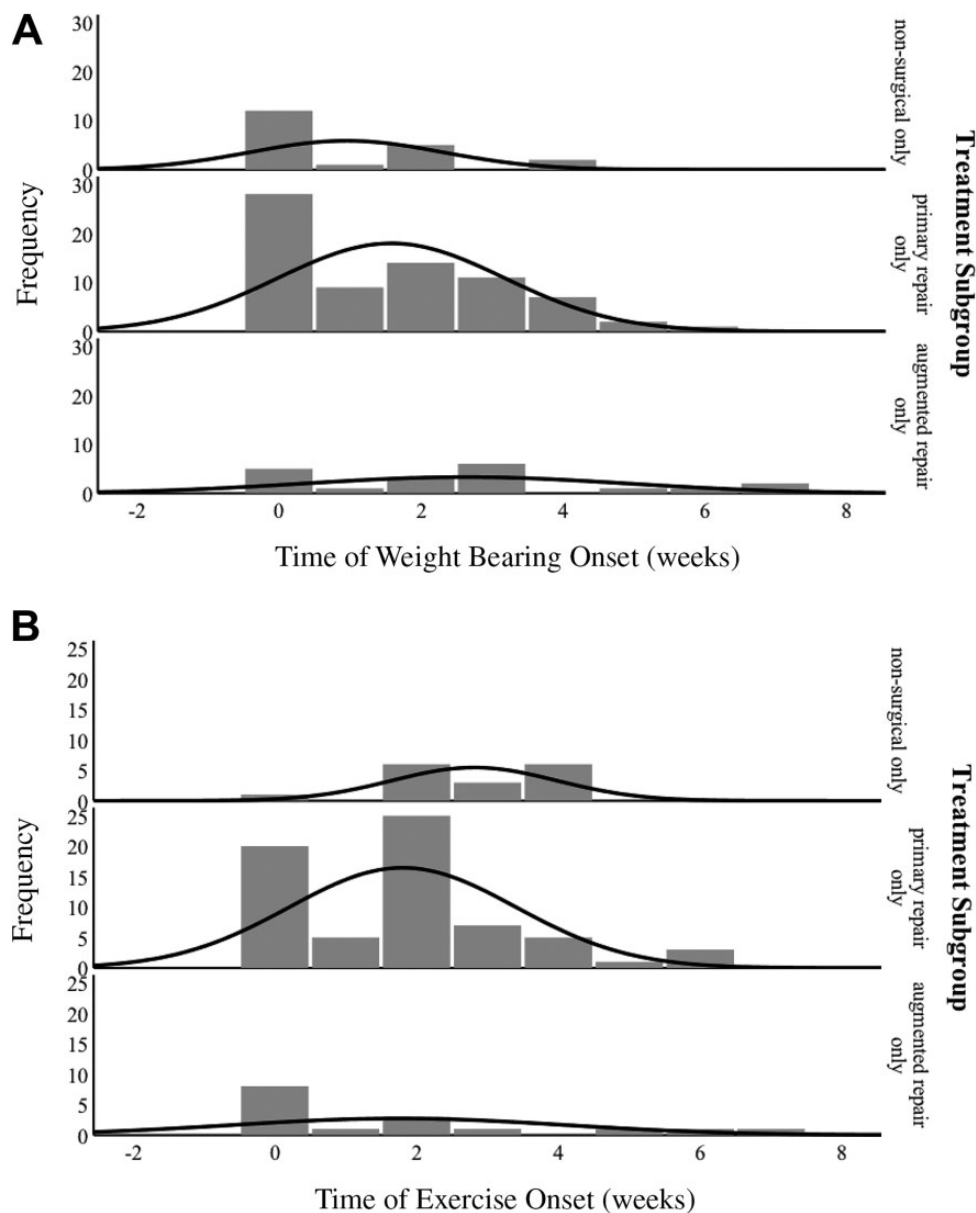


Figure 5. Timing of (A) weightbearing and (B) exercise onset in nonsurgically and surgically managed (primary and augmented repair) patients.

that studies are primarily cohort studies or case series. Although RCTs had significantly more participants on average, 73% of studies presenting data from 100 or more individuals were case series or cohort studies. The majority of research has been done on individuals undergoing simple surgical repair (73% of studies), whereas 28% of studies investigated individuals managed nonsurgically. It seems that little research is available on rehabilitative strategies for nonsurgically managed individuals, which is potentially concerning given trends of increasing numbers of patients managed without surgery.^{61,177,178} Moving forward, it seems that tensile loading could be an area for rehabilitation protocol improvement. We found that only 1 in 2 studies included tensile-type loading, which has been suggested

in basic science and mechanistic studies^{6,7,59,174} to be of importance in the recovery of this patient population. Additionally, a variety of orthoses are used in immobilizing patients—casts, unhinged walking boots with wedging, hinged walking boots—and the effect of these devices on tendon healing from a mechanistic standpoint is not well-described, with 1 study comparing foot position between strategies.⁵⁶ The area of early functional rehabilitation continues to have great research potential, but standardizing outcomes and clearly stating rehabilitative protocols should be a focus moving forward.

Studies aimed at improving Achilles tendon rupture outcomes have used early functional rehabilitation, but this term has been applied without a well-established

TABLE 1
Outcome Measures Used^a

Outcome Measure	No. of Studies
Patient-reported outcome (total)	89
Achilles tendon Total Rupture Score	27
Foot and Ankle Outcome Score	3
No information provided	1
Other patient-reported outcome	43
Survey-based functional outcome (total)	50
AOFAS	33
Leppilahti score	12
Thermann score	12
Functional outcome (total)	130
Ankle range of motion	84
Strength	76
Calf circumference	69
Heel-rise	56
Biomechanics/gait analysis	21
Other	39
Tendon properties (total)	53
Morphology	43
Biology (cellular studies)	1
Other	32

^aAOFAS, American Orthopedic Foot and Ankle Score.

definition. Without a standardized definition, caution should be used when comparing outcomes between studies or pooling data from multiple studies, as the intervention could be very different even if treatment is labeled “early functional rehabilitation.” This study was intended to describe trends across the literature regarding type and timing of early rehabilitation to synthesize an explicit definition. Therefore, the results of this study cannot be taken in a prescriptive sense, because efficacy of treatment protocols was not assessed. We intentionally took a broad approach to study inclusion, and it is important to consider that the Downs & Black checklist can substantially favor RCTs over even very large cohort studies and case series.

Clinically, the findings of this systematic review suggest that in most cases, early functional rehabilitation begins within the first 2 weeks after treatment initiation in individuals with Achilles tendon rupture. Weightbearing and range of motion are commonly used intervention strategies; however, a growing body of literature is using additional rehabilitative strategies such as strengthening interventions and general conditioning. Although general foot and ankle functional scores are regularly reported, several outcomes more specific to this patient population could be considered to assess patient response to treatment.

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REFERENCES

- Agres AN, Gehlen TJ, Arampatzis A, Taylor WR, Duda GN, Manegold S. Short-term functional assessment of gait, plantarflexor strength, and tendon properties after Achilles tendon rupture. *Gait Posture*. 2018;62:179-185.
- Aisaiding A, Wang J, Maimaiti R, et al. A novel minimally invasive surgery combined with early exercise therapy promoting tendon regeneration in the treatment of spontaneous Achilles tendon rupture. *Injury*. 2018;49(3):712-719.
- Aktas S, Kocaoglu B, Nalbantoglu U, Seyhan M, Guven O. End-to-end versus augmented repair in the treatment of acute Achilles tendon ruptures. *J Foot Ankle Surg*. 2007;46(5):336-340.
- Al-Mouazzen L, Rajakulendran K, Najefi A, Ahad N. Percutaneous repair followed by accelerated rehabilitation for acute Achilles tendon ruptures. *J Orthop Surg (Hong Kong)*. 2015;23(3):352-356.
- Alviti F, Gurzi M, Santilli V, et al. Achilles tendon open surgical treatment with platelet-rich fibrin matrix augmentation: biomechanical evaluation. *J Foot Ankle Surg*. 2017;56(3):581-585.
- Andersson T, Eliasson P, Aspenberg P. Tissue memory in healing tendons: short loading episodes stimulate healing. *J Appl Physiol*. 2009;107:417-421.
- Andersson T, Eliasson P, Hammerman M, Sandberg O, Aspenberg P. Low-level mechanical stimulation is sufficient to improve tendon healing in rats. *J Appl Physiol*. 2012;113(9):1398-1402.
- Aoki M, Ogiwara N, Ohta T, Nabeta Y. Early active motion and weight-bearing after cross-stitch Achilles tendon repair. *Am J Sports Med*. 1998;26(6):794-800.
- Aspenberg P, Schepull T. Substantial creep in healing human Achilles tendons: a pilot study. *Muscles Ligaments Tendons J*. 2015;5(3):151-155.
- Assal M, Jung M, Stern R, Rippstein P, Delmi M, Hoffmeyer P. Limited open repair of Achilles tendon ruptures. *J Bone Joint Surg*. 2002;84(2):161-170.
- Aujla R, Kumar A, Bhatia M. Non-surgical treatment of Achilles rupture: does duration in functional weight bearing orthosis matter? *Foot Ankle Surg*. 2016;22(4):254-258.
- Aujla R, Patel S, Jones A, Bhatia M. Predictors of functional outcome in non-operatively managed Achilles tendon ruptures. *Foot Ankle Surg*. 2018;24(4):336-341.
- Bäcker HC, Yenchak AJ, Trofa DP, Vosseller JT. Strength measurement after Achilles tendon repair. *Foot Ankle Spec*. 2019;12(5):471-479.
- Barfod KW, Bencke J, Lauridsen HB, Ban I, Ebskov L, Troelsen A. Nonoperative dynamic treatment of acute Achilles tendon rupture: the influence of early weight-bearing on clinical outcome: a blinded, randomized controlled trial. *J Bone Joint Surg Am*. 2014;96(18):1497-1503.
- Barfod KW, Bencke J, Lauridsen HB, Dippmann C, Ebskov L, Troelsen A. Nonoperative, dynamic treatment of acute Achilles tendon rupture: influence of early weightbearing on biomechanical properties of the plantar flexor muscle-tendon complex—a blinded, randomized, controlled trial. *J Foot Ankle Surg*. 2015;54(2):220-226.
- Baumfeld D, Baumfeld T, Spiezia F, Nery C, Zambelli R, Maffulli N. Isokinetic functional outcomes of open versus percutaneous repair following Achilles tendon tears. *Foot Ankle Surg*. 2019;25(4):503-506.
- Bevoni R, Angelini A, D'Apote G, et al. Long term results of acute Achilles repair with triple-bundle technique and early rehabilitation protocol. *Injury*. 2014;45(8):1268-1274.
- Bhattacharyya M, Gerber B. Mini-invasive surgical repair of the Achilles tendon—does it reduce post-operative morbidity? *Int Orthop*. 2009;33:151-156.
- Bhattacharyya M, Gerber B. Minimally-invasive surgical repair of ruptured Achilles tendon as a day case procedure with early full weight bearing. *Journal of One-day Surgery*. 17(3):70-75.
- Bostick GP, Jomha NM, Suchak AA, Beaupré LA. Factors associated with calf muscle endurance recovery 1 year after Achilles tendon rupture repair. *J Orthop Sports Phys Ther*. 2010;40(6):345-351.

21. Braunstein M, Baumbach SF, Boecker W, Carmont MR, Polzer H. Development of an accelerated functional rehabilitation protocol following minimal invasive Achilles tendon repair. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(3):846-853.
22. Brorsson A, Silbernagel KG, Olsson N, Helander KN. Calf muscle performance deficits remain 7 years after an Achilles tendon rupture. *Am J Sports Med.* 2017;46(2):470-477.
23. Brorsson A, Willy RW, Tranberg R, Grävare Silbernagel K. Heel-rise height deficit 1 year after Achilles tendon rupture relates to changes in ankle biomechanics 6 years after injury. *Am J Sports Med.* 2017;45(13):3060-3068.
24. Brumann M, Baumbach SF, Mutschler W, Polzer H. Accelerated rehabilitation following Achilles tendon repair after acute rupture—development of an evidence-based treatment protocol. *Injury.* 2014;45(11):1782-1790.
25. Buchgraber A, Pässler HH. Percutaneous repair of Achilles tendon rupture: immobilization versus functional postoperative treatment. *Clin Orthop Relat Res.* 1997;341:113-122.
26. Calder JDF, Saxby TS. Early, active rehabilitation following mini-open repair of Achilles tendon rupture: a prospective study. *Br J Sports Med.* 2005;39:857-859.
27. Carmont MR, Grävare Silbernagel K, Brorsson A, Olsson N, Maffulli N, Karlsson J. The Achilles tendon resting angle as an indirect measure of Achilles tendon length following rupture, repair, and rehabilitation. *Asia Pac J Sports Med Arthrosc Rehabil Technol.* 2015;2(2):49-55.
28. Carmont MR, Zellers JA, Brorsson A, et al. Functional outcomes of Achilles tendon minimally invasive repair using 4- and 6-strand non-absorbable suture: a cohort comparison study. *Orthop J Sports Med.* 2017;5(8):2325967117723347.
29. Carvalho FA, Kamper SJ. Effects of early rehabilitation following operative repair of Achilles tendon rupture (PEDro synthesis). *Br J Sports Med.* 2016;50(13):829-830.
30. Ceccarelli F, Berti L, Giuriati L, Romagnoli M, Giannini S. Percutaneous and minimally invasive techniques of Achilles tendon repair. *Clin Orthop Relat Res.* 2007;458:188-193.
31. Cetti R, Christensen S-E, Ejsted R, Jensen NM, Jorgensen U. Operative versus nonoperative treatment of Achilles tendon rupture: a prospective randomized study and review of the literature. *Am J Sports Med.* 1993;21:791-799.
32. Cetti R, Henriksen LO, Jacobsen KS. A new treatment of ruptured Achilles tendons: a prospective randomized study. *Clin Orthop Relat Res.* 1994;308:155-165.
33. Chandrakant V, Lozano-Calderon S, McWilliam J. Immediate weight bearing after modified percutaneous Achilles tendon repair. *Foot Ankle Int.* 2012;33(12):1093-1097.
34. Chen H, Ji X, Zhang Q, Liang X, Tang P. Channel-assisted minimally invasive repair of acute Achilles tendon rupture. *J Orthop Surg Res.* 2015;10:167.
35. Chiu C-H, Yeh W-L, Tsai M-C, Chang S-S, Hsu K-Y, Chan Y-S. Endoscopy-assisted percutaneous repair of acute Achilles tendon tears. *Foot Ankle Int.* 2013;34(123):1168-1176.
36. Chmielnicki M, Prokop A. Zwipp percutaneous suture of the Achilles tendon with the Dresden instruments. *Z Orthop Unfall.* 2016;154:303-305.
37. Collins R, Sudlow A, Loizou C, Loveday DT, Smith G. Closing the gap on Achilles tendon rupture: a cadaveric study quantifying the tendon apposition achieved with commonly used immobilisation practices. *Foot Ankle Surg.* 2018;24(2):124-127.
38. Costa ML, MacMillan K, Halliday D, et al. Randomised controlled trials of immediate weight-bearing mobilisation for rupture of the tendo Achillis. *J Bone Joint Surg Br.* 2006;88(1):69-77.
39. Costa ML, Shepstone L, Darrach C, Marshall T, Donell ST. Immediate full-weight-bearing mobilisation for repaired Achilles tendon ruptures: a pilot study. *Injury.* 2003;34:874-876.
40. Čretnik A, Kosanovic M, Smrkolj V. Percutaneous versus open repair of the ruptured Achilles tendon: a comparative study. *Am J Sports Med.* 2005;33(9):1369-1379.
41. Čretnik A, Kosanović M, Smrkolj V. Percutaneous suturing of the ruptured Achilles tendon under local anesthesia. *J Foot Ankle Surg.* 2004;43(2):72-81.
42. De Carli A, Lanzetti RM, Ciompi A, et al. Can platelet-rich plasma have a role in Achilles tendon surgical repair? *Knee Surg Sports Traumatol Arthrosc.* 2016;24(7):2231-2237.
43. De la Fuente C, Peña y Lillo R, Carreño G, Marambio H. Prospective randomized clinical trial of aggressive rehabilitation after acute Achilles tendon ruptures repaired with Dresden technique. *Foot (Edinb).* 2016;26:15-22.
44. De la Fuente CI, Lillo RPY, Campillo RR, et al. Medial gastrocnemius myotendinous junction displacement and plantar-flexion strength in patients treated with immediate rehabilitation after Achilles tendon repair. *J Athl Train.* 2016;51(12):1013-1021.
45. Delgado-Brambila H, Cristiani DG, Tinajero EC, Burgos-Eliás V. Reparación de ruptura del tendón calcáneo y rehabilitación temprana. *Acta Ortopédica Mex.* 2012;26(2):50-89.
46. Ding W, Yan W, Zhu Y, Liu Z. Treatment of acute and closed Achilles tendon ruptures by minimally invasive tenocutaneous suturing. *Ulus Travma Acil Cerrahi Derg.* 2012;18(5):405-410.
47. Ding WG, Zhu YP, Yan WH. Treatment of acute and closed Achilles tendon ruptures by minimally invasive tenocutaneous suturing. *J Foot Ankle Surg.* 2013;52(2):143-146.
48. Dolphin P, Bainbridge K, Mackenney P, Dixon J. Functional dynamic bracing and functional rehabilitation for Achilles tendon ruptures: a case series. *Physiotherapy Practice and Research.* 2016;37(2):119-125.
49. Domeij-Arverud E, Labruto F, Latifi A, Nilsson G, Edman G, Ackermann PW. Intermittent pneumatic compression reduces the risk of deep vein thrombosis during postoperative lower limb immobilisation: a prospective randomised trial of acute ruptures of the Achilles tendon. *Bone Joint J.* 2015;97(5):675-680.
50. Don R, Ranavolo A, Cacchio A, et al. Relationship between recovery of calf-muscle biomechanical properties and gait pattern following surgery for Achilles tendon rupture. *Clin Biomech (Bristol, Avon).* 2007;22:211-220.
51. Doral MN. What is the effect of the early weight-bearing mobilisation without using any support after endoscopy-assisted Achilles tendon repair? *Knee Surg Sports Traumatol Arthrosc.* 2013;21:1378-1384.
52. Dos Santos Gomes CT. Ruptura do tendão de Aquiles: tratamento cirúrgico, mobilização e carga precoces. *Rev Bras Ortop.* 1998;33(12):951-958.
53. Ebinesan AD, Sarai BS, Walley GD, Maffulli N. Conservative, open or percutaneous repair for acute rupture of the Achilles tendon. *Disabil Rehabil.* 2008;30:1721-1725.
54. Ecker TM, Bremer AK, Krause FG, Müller T, Weber M. Prospective use of a standardized nonoperative early weightbearing protocol for Achilles tendon rupture: 17 years of experience. *Am J Sports Med.* 2016;44(4):1004-1010.
55. El-Akkawi AI, Joanroy R, Barfod KW, Kallemose T, Kristensen SS, Viberg B. Effect of early versus late weightbearing in conservatively treated acute Achilles tendon rupture: a meta-analysis. *J Foot Ankle Surg.* 2018;57(2):346-352.
56. Ellison P, Molloy A, Mason LW. Early protected weightbearing for acute ruptures of the Achilles tendon: do commonly used orthoses produce the required equinus? *J Foot Ankle Surg.* 2017;56(5):960-963.
57. Fernández-Fairén M, Gimeno C. Augmented repair of Achilles tendon ruptures. *Am J Sports Med.* 1997;25(2):177-181.
58. Fitzgibbons RE, Hefferon J, Hill J. Percutaneous Achilles tendon repair. *Am J Sports Med.* 1993;21(5):724-727.
59. Freedman B, Gordon J, Bhatt P, et al. Nonsurgical treatment and early return to activity leads to improved Achilles tendon fatigue mechanics and functional outcomes during early healing in an animal model. *J Orthop Res.* 2016;34(12):2172-2180.
60. Gaiani L, Bertelli R, Palmonari M. Dynamic percutaneous repair of the ruptured tendo Achillis. *Eur J Orthop Surg Traumatol.* 2012;22:709-712.
61. Ganestam A, Kallemose T, Troelsen A, Barfod KW. Increasing incidence of acute Achilles tendon rupture and a noticeable decline in surgical treatment from 1994 to 2013: a nationwide registry study of

- 33,160 patients. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(12):3730-3737.
62. Garrido IM, Deval JC, Bosch MN, Mediavilla DH, Garcia VP, González MS. Treatment of acute Achilles tendon ruptures with Achillon device: clinical outcomes and kinetic gait analysis. *Foot Ankle Surg.* 2010;16(4):189-194.
 63. Geremia JM, Bobbert MF, Casa Nova M, et al. The structural and mechanical properties of the Achilles tendon 2 years after surgical repair. *Clin Biomech (Bristol, Avon).* 2015;30(5):485-492.
 64. Gigante A, Moschini A, Verdenelli A, Del Torto M, Ulisse S, De Palma L. Open versus percutaneous repair in the treatment of acute Achilles tendon rupture: a randomized prospective study. *Knee Surg Sports Traumatol Arthrosc.* 2008;16:204-209.
 65. Gorschewsky O, Pitzl M, Pütz A, Klakow A, Neumann W. Percutaneous repair of acute Achilles tendon rupture. *Foot Ankle Int.* 2004;25(4):219-224.
 66. Gorschewsky O, Vogel U, Schweizer A, van Laar B. Percutaneous tenodesis of the Achilles tendon: a new surgical method for the treatment of acute Achilles tendon rupture through percutaneous tenodesis. *Injury.* 1999;30:315-321.
 67. Groetelaers RPTGC, Janssen L, van der Velden J, et al. Functional treatment or cast immobilization after minimally invasive repair of an acute Achilles tendon rupture: prospective, randomized trial. *Foot Ankle Int.* 2014;35(8):771-778.
 68. Gwynne-Jones DP, Sims M, Handcock D. Epidemiology and outcomes of acute Achilles tendon rupture with operative or nonoperative treatment using an identical functional bracing protocol. *Foot Ankle Int.* 2011;32:337-343.
 69. Hansen M, Christensen M, Budolfson T, et al. Achilles tendon total rupture score at 3 months can predict patients' ability to return to sport 1 year after injury. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(4):1365-1371.
 70. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-381.
 71. Heikkinen J, Lantto I, Flinkkila T, et al. Soleus atrophy is common after the nonsurgical treatment of acute Achilles tendon ruptures. *Am J Sports Med.* 2017;45(6):1395-1404.
 72. Heikkinen J, Lantto L, Flinkkila T, et al. Augmented compared with nonaugmented surgical repair after total Achilles rupture: results of a prospective randomized trial with thirteen or more years of follow-up. *J Bone Joint Surg.* 2016;98:85-92.
 73. Henríquez H, Muñoz R, Carcuro G, Bastías C. Is percutaneous repair better than open repair in acute Achilles tendon rupture? *Clin Orthop Relat Res.* 2012;470:998-1003.
 74. Holm C, Kjaer M, Eliasson P. Achilles tendon rupture—treatment and complications: a systematic review. *Scand J Med Sci Sports.* 2015;25(1):e1-e10.
 75. Holmenschlager F, Schubert S, Winckler S. Achilles tendon rupture: early dynamic mobilisation after surgery. *Zentralbl Chir.* 2002;127:519-522.
 76. Horter M, Horter M, Wetterkamp D, Rieger H. Offene rekonstruktion der Achillessehnenruptur—wann und wie? *Chir Praxis.* 2007;67:611-620.
 77. Hrnack SA, Crates JM, Barber FA. Primary Achilles tendon repair with mini-dorsolateral incision technique and accelerated rehabilitation. *Foot Ankle Int.* 2012;33:848-851.
 78. Huang J, Wang C, Ma X, Wang X, Zhang C, Chen L. Rehabilitation regimen after surgical treatment of acute Achilles tendon ruptures: a systematic review with meta-analysis. *Am J Sports Med.* 2015;43(4):1008-1016.
 79. Huffer D, Hing W, Newton R, Clair M. Strength training for plantar fasciitis and the intrinsic foot musculature: a systematic review. *Phys Ther Sport.* 2017;24(2016):44-52.
 80. Hüfner T, Wohlfarth K, Fink M, Thermann H, Rollnik JD. EMG monitoring during functional non-surgical therapy of Achilles tendon rupture. *Foot Ankle Int.* 2002;23(7):614-618.
 81. Hüfner TM, Brandes DB, Thermann H, Richter M, Knobloch K, Krettek C. Long-term results after functional nonoperative treatment of Achilles tendon rupture. *Foot Ankle Int.* 2006;27:167-171.
 82. Hutchison AM, Topliss C, Beard D, Evans RM, Williams P. The treatment of a rupture of the Achilles tendon using a dedicated management programme. *Bone Joint J.* 2015;97(4):510-515.
 83. Jackson G, Sinclair VF, McLaughlin C, Barrie J. Outcomes of functional weight-bearing rehabilitation of Achilles tendon ruptures. *Orthopedics.* 2013;36(8):e1053-e1059.
 84. Jacob KM, Paterson R. Surgical repair followed by functional rehabilitation for acute and chronic Achilles tendon injuries: excellent functional results, patient satisfaction and no reruptures. *ANZ J Surg.* 2007;77(4):287-291.
 85. Jallageas R, Bordes J, Daviet J-C, Mabit C, Coste C. Evaluation of surgical treatment for ruptured Achilles tendon in 31 athletes. *Orthop Traumatol Surg Res.* 2013;99(5):577-584.
 86. Jielile J, Sabirhazi G, Chen J, et al. Novel surgical technique and early kinesiotherapy for acute Achilles tendon rupture. *Foot Ankle Int.* 2012;33:1119-1127.
 87. Kangas J, Pajala A, Ohtonen P, Leppilahti J. Achilles tendon elongation after rupture repair: a randomized comparison of 2 postoperative regimens. *Am J Sports Med.* 2007;35:59-64.
 88. Kangas J, Pajala A, Siira P, Hämäläinen M, Leppilahti J. Early functional treatment versus early immobilization in tension of the musculotendinous unit after Achilles rupture repair: a prospective, randomized, clinical study. *J Trauma.* 2003;54(6):1171-1180.
 89. Kaniki N, Willits K, Mohtadi NGH, Fung V, Bryant D. A retrospective comparative study with historical control to determine the effectiveness of platelet-rich plasma as part of nonoperative treatment of acute Achilles tendon rupture. *Arthroscopy.* 2014;30(9):1139-1145.
 90. Karaaslan F, Mermerkaya MU, Cirakli A, Karaoglu S, Duygulu F. Surgical versus conservative treatment following acute rupture of the Achilles tendon: is there a pedobarographic difference? *Ther Clin Risk Manag.* 2016;12:1311-1315.
 91. Karabinas PK, Benetos IS, Lampropoulou-Adamidou K, Romoudis P, Mavrogenis AF, Vlamis J. Percutaneous versus open repair of acute Achilles tendon ruptures. *Eur J Orthop Surg Traumatol.* 2014;24:607-613.
 92. Kauranen K, Kangas J, Leppilahti J. Recovering motor performance of the foot after Achilles rupture repair: a randomized clinical study about early functional treatment vs. early immobilization of Achilles tendon in tension. *Foot Ankle Int.* 2002;23(7):600-605.
 93. Kearney RS, Achten J, Parsons NR, Costa ML. The comprehensive cohort model in a pilot trial in orthopaedic trauma. *BMC Med Res Methodol.* 2011;11(1):39.
 94. Keller A, Ortiz C, Wagner E, Wagner P, Mococain P. Mini-open tenorrhaphy of acute Achilles tendon ruptures: medium-term follow-up of 100 cases. *Am J Sports Med.* 2014;42(3):731-736.
 95. Kerkhoffs GM, Struijs PA, Raaymakers EL, Marti RK. Functional treatment after surgical repair of acute Achilles tendon rupture: wrap vs walking cast. *Arch Orthop Trauma Surg.* 2002;122:102-105.
 96. Kim U, Choi YS, Jang GC, Choi YR. Early rehabilitation after open repair for patients with a rupture of the Achilles tendon. *Injury.* 2017;48(7):1710-1713.
 97. Knobe M, Gradl G, Klos K, et al. Is percutaneous suturing superior to open fibrin gluing in acute Achilles tendon rupture? *Int Orthop.* 2015;39(3):535-542.
 98. Korakakis V, Whiteley R, Tzavara A, Malliaropoulos N. The effectiveness of extracorporeal shockwave therapy in common lower limb conditions: a systematic review including quantification of patient-rated pain reduction. *Br J Sports Med.* 2018;52(6):387-407.
 99. Korkmaz M, Erkoc MF, Yolcu S, Balbaloglu O, Öztürüm Z, Karaaslan F. Weight bearing the same day versus non-weight bearing for 4 weeks in Achilles tendon rupture. *J Orthop Sci.* 2015;20(3):513-516.
 100. Kuskucu M, Mahiroglu M, Solakoglu C, et al. Treatment of rupture of the Achilles tendon with fibrin sealant. *Foot Ankle Int.* 2005;26(10):826-831.

101. Lacoste S, Cherrier B, Féron JM. Intra-operative ultrasonography in the percutaneous tenorrhaphy of acute Achilles tendon ruptures. *Eur J Orthop Surg Traumatol*. 2012;22(7):585-591.
102. Lansdaal JR, Goslings JC, Reichart M, et al. The results of 163 Achilles tendon ruptures treated by a minimally invasive surgical technique and functional aftertreatment. *Injury*. 2007;38:839-844.
103. Lantto I, Heikkinen J, Flinkkila T, et al. A prospective randomized trial comparing surgical and nonsurgical treatments of acute Achilles tendon ruptures. *Am J Sports Med*. 2016;44(9):2406-2414.
104. Lantto I, Heikkinen J, Flinkkila T, et al. Early functional treatment versus cast immobilization in tension after Achilles rupture repair: results of a prospective randomized trial with 10 or more years of follow-up. *Am J Sports Med*. 2015;43(9):2302-2309.
105. Lantto I, Heikkinen J, Flinkkila T, Ohtonen P, Leppilähti J. Epidemiology of Achilles tendon ruptures: increasing incidence over a 33-year period. *Scand J Med Sci Sports*. 2015;25(1):e133-e138.
106. Lapidus LJ, Rosfors S, Ponzer S, et al. Prolonged thromboprophylaxis with dalteparin after surgical treatment of Achilles tendon rupture: a randomized, placebo-controlled study. *J Orthop Trauma*. 2007;21(1):52-57.
107. Lee DK. A preliminary study on the effects of acellular tissue graft augmentation in acute Achilles tendon ruptures. *J Foot Ankle Surg*. 2008;47(1):8-12.
108. Leppilähti J, Lahde S, Forsman K, Kangas J, Kauranen K, Orava S. Relationship between calf muscle size and strength after Achilles rupture repair. *Foot Ankle Int*. 2000;21(4):330-335.
109. Li C-G, Li B, Yang Y-F. Management of acute Achilles tendon rupture with tendon-bundle technique. *J Int Med Res*. 2017;45(1):310-319.
110. Lill H, Moor C, Fecht E, Kalbe P, Echtermeyer V. Achillessehnenruptur—operative oder konservativ funktionelle Behandlung? *Akt Traumatol*. 1996;26:95-100.
111. Lim CS, Lees D, Gwynne-Jones DP. Functional outcome of acute Achilles tendon rupture with and without operative treatment using identical functional bracing protocol. *Foot Ankle Int*. 2018;38(12):1331-1336.
112. Lonžarić D, Krušić A, Dinevski D, Povalej Bržan P, Jesenšek Papež B. Primary surgical repair of acute Achilles tendon rupture: comparative results of three surgical techniques. *Wien Klin Wochenschr*. 2017;129(5-6):176-185.
113. Lorkowski J, Brongel L, Hładki W, et al. Evaluation of long term therapy outcomes for Achilles tendon ruptures. *Pol Przegl Chir*. 2007;79(6):745-756.
114. MacDermid JC, Silbernagel KG. Outcome evaluation in tendinopathy: foundations of assessment and a summary of selected measures. *J Orthop Sports Phys Ther*. 2015;45(11):950-964.
115. Maffulli G, Del Buono A, Richards P, Oliva F, Maffulli N. Conservative, minimally invasive and open surgical repair for management of acute ruptures of the Achilles tendon: a clinical and functional retrospective study. *Muscles Ligaments Tendons J*. 2017;7(1):46-52.
116. Maffulli N, Longo UG, Ronga M, Khanna A, Denaro V. Favorable outcome of percutaneous repair of Achilles tendon ruptures in the elderly. *Clin Orthop Relat Res*. 2010;468:1039-1046.
117. Maffulli N, Tallon C, Wong J, Lim KP, Bleakney R. Early weightbearing and ankle mobilization after open repair of acute midsubstance tears of the Achilles tendon. *Am J Sports Med*. 2003;31(5):692-700.
118. Maffulli N, Tallon C, Wong J, Peng Lim K, Bleakney R. No adverse effect of early weight bearing following open repair of acute tears of the Achilles tendon. *J Sports Med Phys Fitness*. 2003;43(3):367-379.
119. Maffulli N, Thorpe AP, Smith EW. Magnetic resonance imaging after operative repair of Achilles tendon rupture. *Scand J Med Sci Sports*. 2001;11:156-162.
120. Majewski M, Schaeren S, Kohlhaas U, Ochsner PE. Postoperative rehabilitation after percutaneous Achilles tendon repair: early functional therapy versus cast immobilization. *Disabil Rehabil*. 2008;30(20-22):1726-1732.
121. Mandelbaum BR, Myerson MS, Forster R. Achilles tendon ruptures: a new method of repair, early range of motion, and functional rehabilitation. *Am J Sports Med*. 1995;23(4):392-395.
122. Marti R, Werken van derSchutte P, Bast T. Operative repair of ruptured Achilles tendon and functional after-treatment—I: acute rupture. *Neth J Surg*. 1983;35(2):61-64.
123. Martinelli B. Percutaneous repair of the Achilles tendon in athletes. *Bull Hosp Jt Dis*. 2000;59(3):149-152.
124. Mauch M, Ulrich M, Kaelin X, Segesser B, Paul J. Biomechanical evaluation of rehabilitation after surgical repair of Achilles tendon ruptures. *Sportverletz Sportschaden*. 2017;31:222-230.
125. Mavrodontidis A, Lykissas M, Koulouvaris P, Pafilas D, Kontogeorgakos V, Zalavras C. Percutaneous repair of acute Achilles tendon rupture: a functional evaluation study with a minimum 10-year follow-up. *Acta Orthop Traumatol Turc*. 2015;49(6):661-667.
126. Mayer A, Frasson VB, Ott R, Fortuna RO, Vaz MA. Desequilíbrios musculares entre flexores dorsais e plantares do tornozelo após tratamento conservador e acelerado da ruptura do tendão calcâneo. Muscle imbalance between ankle dorsiflexors and plantarflexors after conservative and accelerated treatment. *Fisioter e Pesqui*. 2010;17(2):108-113.
127. McComis GP, Nawoczinski DA, DeHaven K. Functional bracing for rupture of the Achilles tendon: clinical results and analysis of ground-reaction forces and temporal data. *J Bone Joint Surg*. 1997;79(12):1799-1808.
128. McCormack R, Bovard J. Early functional rehabilitation or cast immobilisation for the postoperative management of acute Achilles tendon rupture? A systematic review and meta-analysis of randomised controlled trials. *Br J Sports Med*. 2015;49(20):1329-1335.
129. McNair P, Nordez A, Olds M, Young SW, Cornu C. Biomechanical properties of the plantar flexor muscle-tendon complex 6 months post-rupture of the Achilles tendon. *J Orthop Res*. 2013;31(9):1469-1474.
130. Metz R, van der Heijden GJMG, Verleisdonk E-JMM, Tamminga R, van der Werken C. Recovery of calf muscle strength following Achilles tendon rupture treatment: a comparison between minimally invasive surgery and conservative treatment. *Foot Ankle Spec*. 2009;2(5):219-226.
131. Mezzarobba S, Bortolato S, Giacomazzi A, Fancellu G, Marcovich R, Valentini R. Percutaneous repair of Achilles tendon ruptures with Tenolig: quantitative analysis of postural control and gait pattern. *Foot (Edinb)*. 2012;22(4):303-309.
132. Miller D, Waterston S, Reaper J, Barrass V, Maffulli N. Conservative management, percutaneous or open repair of acute Achilles tendon rupture: a retrospective study. *Scott Med J*. 2005;50(4):160-165.
133. Miyamoto W, Imade S, Innami K, Kawano H, Takao M. Acute Achilles tendon rupture treated by double side-locking loop suture technique with early rehabilitation. *Foot Ankle Int*. 2017;38(2):167-173.
134. Moberg A, Nordgren B, Solveborn S. Surgically repaired Achilles tendon ruptures with postoperative mobile ankle cast: a 12-month follow-up study with an isokinetic and a dynamic muscle function test. *Scand J Med Sci Sports*. 1992;2(4):231-233.
135. Möller M, Kälébo P, Tidebrant G, Movin T, Karlsson J. The ultrasonographic appearance of the ruptured Achilles tendon during healing: a longitudinal evaluation of surgical and nonsurgical treatment, with comparisons to MRI appearance. *Knee Surg Sports Traumatol Arthrosc*. 2002;10:49-56.
136. Möller M, Lind K, Movin T, Karlsson J. Calf muscle function after Achilles tendon rupture: a prospective, randomised study comparing surgical and non-surgical treatment. *Scand J Med Sci Sports*. 2002;12(1):9-16.
137. Moller M, Movin T, Granhed H, Lind K, Faxen E, Karlsson J. Acute rupture of tendon Achilles: a prospective randomised study of comparison between surgical and non-surgical treatment. *J Bone Joint Surg Br*. 2001;83(6):843-848.
138. Mortensen HM, Skov O, Jensen PE. Early motion of the ankle after operative treatment of a rupture of the Achilles tendon: a prospective, randomized clinical and radiographic study. *J Bone Joint Surg*. 1999;81(7):983-990.
139. Mortensen N, Saether J, Steinke M, Staehr H, Mikkelsen S. Separation of tendon ends after Achilles tendon repair: a prospective, randomized, multicenter study. *Orthopedics*. 1992;15(8):899-903.

140. Motta P, Errichiello C, Pontini I. Achilles tendon rupture: a new technique for easy surgical repair and immediate movement of the ankle and foot. *Am J Sports Med.* 1997;25(2):172-176.
141. Mukundan C, El Hussein M, Rayan F, Salim J, Budgen A. "Mini-open" repair of acute tendo Achilles ruptures—the solution? *Foot Ankle Surg.* 2010;16(3):122-125.
142. Mullaney MJ, McHugh MP, Tyler TF, Nicholas SJ, Lee SJ. Weakness in end-range plantar flexion after Achilles tendon repair. *Am J Sports Med.* 2006;34:1120-1125.
143. Neumayer F, Mouhsine E, Arlettaz Y, Gremion G, Wettstein M, Crevoisier X. A new conservative-dynamic treatment for the acute ruptured Achilles tendon. *Arch Orthop Trauma Surg.* 2010;130(3):363-368.
144. Nilsson-Helander K, Silbernagel KG, Thomeé R, et al. Acute Achilles tendon rupture: a randomized, controlled study comparing surgical and nonsurgical treatments using validated outcome measures. *Am J Sports Med.* 2010;38(11):2186-2193.
145. O'Connor SR, Tully MA, Ryan B, Bradley JM, Baxter GD, McDonough SM. Failure of a numerical quality assessment scale to identify potential risk of bias in a systematic review: a comparison study. *BMC Res Notes.* 2015;8:224.
146. Ocguder DA, Dogan M, Bektaser SB, Akgun E, Tolunay T, Ugurlu M. Comparison of the open primary repair with augmentation and without augmentation in acute Achilles tendon rupture. *Turkish J Med Sci.* 2011;41(4):639-646.
147. Olsson N, Karlsson J, Eriksson BI, Brorsson A, Lundberg M, Silbernagel KG. Ability to perform a single heel-rise is significantly related to patient-reported outcome after Achilles tendon rupture. *Scand J Med Sci Sports.* 2014;24:152-158.
148. Olsson N, Nilsson-Helander K, Karlsson J, et al. Major functional deficits persist 2 years after acute Achilles tendon rupture. *Knee Surg Sports Traumatol Arthrosc.* 2011;19:1385-1393.
149. Olsson N, Petzold M, Brorsson A, Karlsson J, Eriksson BI, Grävare Silbernagel K. Predictors of clinical outcome after acute Achilles tendon ruptures. *Am J Sports Med.* 2014;42(6):1448-1455.
150. Olsson N, Silbernagel KG, Eriksson BI, et al. Stable surgical repair with accelerated rehabilitation versus nonsurgical treatment for acute Achilles tendon ruptures: a randomized controlled study. *Am J Sports Med.* 2013;41(12):2867-2876.
151. Ozer H, Selek HY, Harput G, Oznur A, Baltaci G. Achilles tendon open repair augmented with distal turnover tendon flap and posterior crural fasciotomy. *J Foot Ankle Surg.* 2016;55(6):1180-1184.
152. Ozkan H, Ege T, Koca K, Can N, Yurttas Y, Tunay S. Pedobarographic measurements after repair of Achilles tendon by minimal invasive surgery. *Acta Orthop Belg.* 2016;82:271-274.
153. Ozkaya U, Parmaksizoglu AS, Kabukcuoglu Y, Sokucu S, Basilgan S. Open minimally invasive Achilles tendon repair with early rehabilitation: functional results of 25 consecutive patients. *Injury.* 2009;40(6):669-672.
154. Peng W-C, Chang Y-P, Chao Y-H, et al. Morphomechanical alterations in the medial gastrocnemius muscle in patients with a repaired Achilles tendon: associations with outcome measures. *Clin Biomech (Bristol, Avon).* 2017;43:50-57.
155. Persson A, Wredmark T. The treatment of total ruptures of the Achilles tendon by plaster immobilisation. *Int Orthop.* 1979;3(2):149-152.
156. Petersen OF, Nielsen MB, Jensen KH, Solgaard S. Randomiseret sammenligning af genanvendelig stovle og letvaegtsgips til behandling af forstegangs akilleseneruptur. *Ugeskr Laeger.* 2002;164:3852-3855.
157. Porter DA, Barnes AF, Rund AM, Kaz AJ, Tyndall JA, Millis AA. Acute Achilles tendon repair: strength outcomes after an acute bout of exercise in recreational athletes. *Foot Ankle Int.* 2014;35(2):123-130.
158. Porter MD, Shadbolt B. Randomized controlled trial of accelerated rehabilitation versus standard protocol following surgical repair of ruptured Achilles tendon. *ANZ J Surg.* 2015;85(5):373-377.
159. Quagliarella L, Sasanelli N, Notarnicola A, Belgiovine G, Moretti L. Comparative functional analysis of two different Achilles tendon surgical repairs. *Foot Ankle Int.* 2010;31(4):306-315.
160. Raikin SM, Garras DN, Krapchev PV. Achilles tendon injuries in a United States population. *Foot Ankle Int.* 2013;34(4):475-480.
161. Reilmann H, Forster E, Weinberg A, Bruggemann F, Peukert J. Conservative functional therapy of closed rupture of the Achilles tendon: treatment approach and analysis of results. *Unfallchirurg.* 1996;99:576-580.
162. Renninger CH, Kuhn K, Fellars T, Youngblood S, Bellamy J. Operative and nonoperative management of Achilles tendon ruptures in active duty military population. *Foot Ankle Int.* 2016;37(3):269-273.
163. Richardson LC, Reitman R, Wilson M. Achilles tendon ruptures: functional outcome of surgical repair with a "pull-out" wire. *Foot Ankle Int.* 2003;24(5):439-443.
164. Richter J, Josten DA, Clasbrummel B, Muhr G. Sportfähigkeit nach konservativ-funktioneller versus operativer Behandlung von akuten Achillessehnenrupturen. *Zentralbl Chir.* 1994;119:538-544.
165. Richter J, Pommer A, Hahn M, David A, Muhr G. Möglichkeiten und Grenzen der funktionell konservativen Therapie akuter Achillessehnenrupturen. *Chirurg.* 1997;68:517-524.
166. Roberts CP, Palmer S, Vince A, Deliss LJ. Dynamised cast management of Achilles tendon ruptures. *Injury.* 2001;32(5):423-426.
167. Rozis M, Benetos I, Karampinas P, Polyzois V, Vlamis J, Pneumatos S. Outcome of percutaneous fixation of acute Achilles tendon ruptures. *Foot Ankle Int.* 2018;39(6):689-693.
168. Saleh M, Marshall PD, Senior R, MacFarlane A. The Sheffield splint for controlled early mobilisation after rupture of the calcaneal tendon: a prospective, randomised comparison with plaster treatment. *J Bone Joint Surg Br.* 1992;74(2):206-209.
169. Sandberg OH, Danmark I, Eliasson P, Aspenberg P. Influence of a lower leg brace on traction force in healthy and ruptured Achilles tendons. *Muscles Ligaments Tendons J.* 2015;5(2):63-67.
170. Saper D, Lybrand K, Creevy W, Li X. Using a posterior compartment fasciotomy and paratenon closure in acute Achilles tendon repair. *Orthopedics.* 2016;39(4):e790-e793.
171. Saw Y, Baltzopoulos V, Lim A, Rostron PKM. Early mobilization Achilles tendon after operative repair of ruptured Achilles tendon. *Injury.* 1993;24(7):479-484.
172. Saxena A, Ewen B, Maffulli N. Rehabilitation of the operated Achilles tendon: parameters for predicting return to activity. *J Foot Ankle Surg.* 2011;50(1):37-40.
173. Schäfer D, Regazzoni P, Hintermann B. Frühfunktionelle Behandlung der operativ versorgten Achillessehnenruptur. *Unfallchirurg.* 2002;105(8):699-702.
174. Schepull T, Aspenberg P. Early controlled tension improves the material properties of healing human Achilles tendons after ruptures: a randomized trial. *Am J Sports Med.* 2013;41:2550-2557.
175. Schepull T, Kvist J, Andersson C, Aspenberg P. Mechanical properties during healing of Achilles tendon ruptures to predict final outcome: a pilot Roentgen stereophotogrammetric analysis in 10 patients. *BMC Musculoskelet Disord.* 2007;8:116.
176. Scott A, Docking S, Vicenzino B, et al. Sports and exercise-related tendinopathies: a review of selected topical issues by participants of the second International Scientific Tendinopathy Symposium (ISTS) Vancouver 2012. *Br J Sports Med.* 2013;47:536-544.
177. Sheth U, Wasserstein D, Jenkinson R, Moineddin R, Kreder H, Jaglal S. Practice patterns in the care of acute Achilles tendon ruptures. *Bone Joint J.* 2017;99(12):1629-1636.
178. Sheth U, Wasserstein D, Jenkinson R, Moineddin R, Kreder H, Jaglal SB. The epidemiology and trends in management of acute Achilles tendon ruptures in Ontario, Canada. *Bone Joint J.* 2017;99(1):78-86.
179. Solveborn S, Moberg A. Immediate free ankle motion after surgical repair of acute Achilles tendon ruptures. *Am J Sports Med.* 1994;22(5):607-610.
180. Sorrenti S. Achilles tendon rupture: effect of early mobilization in rehabilitation after surgical repair. *Foot Ankle Int.* 2006;27(6):407-410.
181. Speck M, Klauke K. Early full weightbearing and functional treatment after surgical repair of acute Achilles tendon rupture. *Am J Sports Med.* 1998;26(6):789-793.

182. Steele GJ, Harter RA, Ting AJ. Comparison of functional ability following percutaneous and open surgical repairs of acutely ruptured Achilles tendons. *J Sport Rehabil.* 1993;2:115-127.
183. Strauss E, Ishak C, Jazrawi L, Sherman O, Rosen J. Operative treatment of acute Achilles tendon ruptures: an institutional review of clinical outcomes. *Injury.* 2007;38(7):832-838.
184. Suchak A, Bostick G, Beaupre L, Durand D, Jomha N. The influence of early weight-bearing compared with non-weight-bearing after surgical repair of the Achilles tendon. *J Bone Joint Surg.* 2008; 90(9):1876-1883.
185. Swennergren Hansen M, Weisskirchner Barfod K, Tange Kristensen M. Development and reliability of the Achilles tendon length measure and comparison with the Achilles tendon resting angle on patients with an Achilles tendon rupture. *Foot Ankle Surg.* 2017;23(4): 275-280.
186. Tarniță DN, Tarniță D, Grecu DC, Calafeteanu DM, Căpitănescu B. New technical procedure involving Achilles tendon rupture treatment through transcutaneous suture. *Rom J Morphol Embryol.* 2016; 57(1):211-214.
187. Tezeren G, Kuru I. Augmentation vs nonaugmentation techniques for open repairs of Achilles tendon ruptures with early functional treatment: a prospective randomized study. *J Sports Sci Med.* 2006;5(4): 607-614.
188. Thermann H, Zwipp H. Achillessehnenruptur. *Orthopade.* 1989;18: 321-335.
189. Thermann H, Zwipp H, Tschern H. Functional treatment concept of acute rupture of the Achilles tendon: 2 years results of a prospective randomized study. *Unfallchirurg.* 1995;98(1):21-32.
190. Troop RL, Losse GM, Lane JG, Robertson DB, Hastings PS, Howard ME. Early motion after repair of Achilles tendon ruptures. *Foot Ankle Int.* 1995;16(11):705-709.
191. Twaddle BC, Poon P. Early motion for Achilles tendon ruptures: is surgery important? A randomized, prospective study. *Am J Sports Med.* 2007;35:2033-2038.
192. Vadalá A, De Carli A, Vulpiani M, et al. Clinical, functional and radiological results of Achilles tenorrhaphy surgically treated with mini-open technique. *J Sports Med Phys Fitness.* 2012;52:616-621.
193. Valkering KP, Aufwerber S, Ranuccio F, Lunini E, Edman G, Ackermann PW. Functional weight-bearing mobilization after Achilles tendon rupture enhances early healing response: a single-blinded randomized controlled trial. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(6):1807-1816.
194. Vavra-Hadžiahmetovic N, Hadžiahmetovic Z, Smajlovic F. Physical therapy in conservative (functional) treatment of acute Achilles tendon rupture. *Med Arh.* 2000;54(2):121-122.
195. Walz M, Cramer J, Mollenhoff G, Muhr G. Ultrasonographic monitoring of conservative-functional treatment of rupture of the Achilles tendon. *Orthopade.* 1993;22(5):317-322.
196. Weber M, Niemann M, Lanz R, Müller T. Nonoperative treatment of acute rupture of the Achilles tendon: results of a new protocol and comparison with operative treatment. *Am J Sports Med.* 2003;31(5): 685-691.
197. Westin O, Nilsson Helander K, Gräware Silbernagel K, Möller M, Kälebo P, Karlsson J. Acute ultrasonography investigation to predict reruptures and outcomes in patients with an Achilles tendon rupture. *Orthop J Sports Med.* 2016;4(10):2325967116667920.
198. Williamson PR, Altman DG, Bagley H, et al. The COMET Handbook: version 1.0. *Trials.* 2017;18(suppl 3):280.
199. Willits K, Amendola A, Bryant D, et al. Operative versus nonoperative treatment of acute Achilles tendon ruptures: a multicenter randomized trial using accelerated functional rehabilitation. *J Bone Joint Surg.* 2010;92(17):2767-2775.
200. Willy RW, Brorsson A, Powell HC, Willson JD, Tranberg R, Gräware Silbernagel K. Elevated knee joint kinetics and reduced ankle kinetics are present during jogging and hopping after Achilles tendon ruptures. *Am J Sports Med.* 2017;45(5):1124-1133.
201. Wredmark T, Carlstedt CA. Tendon elongation and muscle function after repair of Achilles tendon rupture. *Scand J Med Sci Sports.* 1992;2(3):139-142.
202. Yotsumoto T, Miyamoto W, Uchio Y. Novel approach to repair of acute Achilles tendon rupture: early recovery without postoperative fixation or orthosis. *Am J Sports Med.* 2010;38:287-292.
203. Zayni R, Coursier R, Zakaria M, et al. Activity level recovery after acute Achilles tendon rupture surgically repaired: a series of 29 patients with a mean follow-up of 46 months. *Muscles Ligaments Tendons J.* 2017;7(1):69-77.
204. Zell RA, Santoro VM. Augmented repair of acute Achilles tendon ruptures. *Foot Ankle Int.* 2000;21(6):469-474.

APPENDIX

TABLE A1
Search String

Ovid Technologies

Database: Embase <1974 to 2017 Week 14>

Search Strategy:

1 achilles tendon rupture/

2 (calcaneus or calcanea* or achillis or achillean or achilles).mp.

3 (rupture* or injur* or tear or tears or lesion*).mp.

4 2 and 3

5 1 or 4

6 exp rehabilitation/

7 rehabilitation.fs.

8 (rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation).mp.

9 mobilization/

10 exp immobilization/

11 or/6-10

12 5 and 11

(continued)

Table A1 (continued)

Database: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) <1946 to Present>

Search Strategy:

- 1 Achilles Tendon/
- 2 exp Rupture/
- 3 (calcaneus or calcanea* or achillis or achillean or achilles).mp.
- 4 (rupture* or injur* or tear or tears or lesion*).mp.
- 5 1 or 3
- 6 2 or 4
- 7 5 and 6
- 8 exp Rehabilitation/
- 9 rehabilitation.fs.
- 10 (rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation).mp.
- 11 exp Immobilization/
- 12 or/8-11
- 13 7 and 12

Database: Pedro

Search Strategy:

- 1 Achilles tendon rupture

Database: CINAHL

Search Strategy:

- 1 (MH "Achilles Tendon Rupture")
- 2 calcaneus or calcanea* or achillis or achillean or achilles
- 3 rupture* or injur* or tear or tears or lesion*
- 4 #2 and #3
- 5 #1 or #4
- 6 (MH "Rehabilitation+")
- 7 rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation
- 8 (MH "Immobilization")
- 9 #6 or #7 or #8
- 10 #5 and #9

Database: Cochrane

Search Strategy:

- 1 MeSH descriptor: [Achilles Tendon] explode all trees
 - 2 (calcaneus or calcanea* or achillis or achillean or achilles): ti, ab
 - 3 MeSH descriptor: [Rupture] explode all trees
 - 4 (rupture* or injur* or tear or tears or lesion*): ti, ab
 - 5 #1 or #2
 - 6 #3 or #4
 - 7 #5 or #6
 - 8 MeSH descriptor: [Rehabilitation] explode all trees
 - 9 rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation
 - 10 #8 or #9
 - 11 #7 and #10
-

TABLE A2
Summary of Interventions in All Included Studies^a

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Nonsurgical Management											
Aujla ¹² (2018)	No	236	*	*							22
Aujla ¹¹ (2016)	No	88	*	*							21
Barfod ¹⁴ (2014)	Yes	60	*	*							24
Dolphin ⁴⁸ (2016)	No	25	*	*							20
Ecker ⁵⁴ (2016)	No	171	*	*		*	*	*			16
Hüfner ⁸¹ (2006)	No	125	*	*	*	*				*	15
Hüfner ⁸⁰ (2002)	No	21	*	*		*	*	*		*	8
Kaniki ⁸⁹ (2014)	No	145	*	*	*		*	*	*		20
Korkmaz ⁹⁹ (2015)	No	47	*								21
McComis ¹²⁷ (1997)	No	30	*	*	*					*	20
McNair ¹²⁹ (2013)	No	38	*								14
Neumayer ¹⁴³ (2010)	No	57	*	*					*	*	16
Persson ¹⁵⁵ (1979)	No	20	*								16
Petersen ¹⁵⁶ (2002) ^b	No	50	*								19
Reilmann ¹⁶¹ (1996) ^c	No	132	*		*			*		*	14
Roberts ¹⁶⁶ (2001)	No	49	*	*							14
Saleh ¹⁶⁸ (1992)	No	40	*	*	*					*	17
Swennergren ¹⁸⁵ (2017)	No	28	*	*							19
Vavra-Hadziahmetovic ¹⁹⁴ (2000)	No	19	*	*	*	*	*			*	9
Walz ¹⁹⁵ (1993) ^c	No	22	*	*							15
Surgical Management											
Agres ¹ (2018)	No	14	*	*	*	*			*		17
Aisaiding ² (2018)	No	52	*	*	*	*		*			21
Aktas ³ (2007)	No	30	*	*							19
Al-Mouazzen ⁴ (2015)	No	30	*	*				*			15
Alviti ⁵ (2017)	No	20	*	*						*	20
Aoki ⁸ (1998)	No	22	*	*	*						17
Aspenberg ⁹ (2015)	No	16	*	*							13
Assal ¹⁰ (2002)	No	87	*	*			*	*			18
Baumfeld ¹⁶ (2019)	No	38	*								16
Bevoni ¹⁷ (2014)	No	66	*	*		*	*			*	20
Bhattacharyya ¹⁸ (2009)	Yes	59	*							*	12
Buchgraber ²⁵ (1997)	No	48	*	*	*	*				*	16
Calder ²⁶ (2005)	No	46	*	*							13
Carmont ²⁷ (2015)	No	26	*	*						*	18
Carmont ²⁸ (2017)	No	70	*	*							21
Ceccarelli ³⁰ (2007)	No	24	*	*			*			*	19
Cetti ³² (1994)	No	60	*	*						*	19
Chandrakant ³³ (2012)	No	52	*	*	*	*				*	19
Chen ³⁴ (2015)	No	82		*						*	22
Chiu ³⁵ (2013)	No	19	*								14
Chmielnicki ³⁶ (2016) ^c	No	212	*								15
Costa ³⁹ (2003)	No	28	*							*	18
Čretnik ⁴¹ (2004)	Yes	237	*	*						*	20
De Carli ⁴² (2016)	No	30	*	*							20
De la Fuente ⁴³ (2016)	No	39	*	*						*	23
De la Fuente ⁴⁴ (2016)	No	26	*	*	*				*		18
Delgado-Brambila ⁴⁵ (2012) ^d	No	35		*						*	13
Ding ⁴⁶ (2012)	Yes	88				*					16
Don ⁵⁰ (2007)	No	49	*	*							15
Doral ⁵¹ (2013)	No	32	*	*	*					*	17
Dos Santos Gomes ⁵² (1998) ^e	No	13	*	*		*	*				10
Fernández-Fairén ⁵⁷ (1997)	No	29	*	*	*		*	*			13
Fitzgibbons ⁵⁸ (1993)	No	14	*								16
Gaiani ⁶⁰ (2012)	No	80	*				*				11

(continued)

Table A2 (continued)

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Garrido ⁶² (2010)	No	18	*	*							16
Geremia ⁶³ (2015)	No	18	*	*	*			*	*		18
Gigante ⁶⁴ (2008)	No	40	*	*							16
Gorschewsky ⁶⁵ (2004)	No	66	*	*	*				*		14
Gorschewsky ⁶⁶ (1999)	No	20	*	*	*						15
Groetelaers ⁶⁷ (2014)	No	60	*	*							21
Heikkinen ⁷² (2016)	No	55	*	*							25
Henríquez ⁷³ (2012)	No	32	*						*	*	14
Holmenschlager ⁷⁵ (2002) ^c	No	45	*	*							14
Horter ⁷⁶ (2007) ^c	No	102	*	*							9
Hrnack ⁷⁷ (2012)	No	15	*	*							15
Jacob ⁸⁴ (2007)	No	36	*	*							12
Jallageas ⁸⁵ (2013)	No	31	*	*		*					20
Jielile ⁸⁶ (2012)	No	107	*	*	*	*	*	*			18
Kangas ⁸⁸ (2003)	Yes	50	*	*				*			22
Karabinas ⁹¹ (2014)	No	34	*								17
Kauranen ⁹² (2002)	No	30	*	*		*					18
Keller ⁹⁴ (2014)	No	100	*								21
Kerkhoffs ⁹⁵ (2002)	No	39	*								16
Kim ⁹⁶ (2017)	No	56	*	*	*						17
Kuskucu ¹⁰⁰ (2005)	No	32	*	*							15
Lacoste ¹⁰¹ (2012)	No	33	*	*							19
Lansdaal ¹⁰² (2007)	No	163	*			*					15
Lapidus ¹⁰⁶ (2007)	No	105	*								24
Lee ¹⁰⁷ (2008)	No	11	*								16
Leppilahti ¹⁰⁸ (2000)	No	85	*								16
Li ¹⁰⁹ (2017)	No	24	*	*							18
Lonzarić ¹¹² (2017)	No	262	*	*							21
Maffulli ¹¹⁶ (2010)	No	35	*	*	*	*					17
Maffulli ¹¹⁷ (2003)	Yes	53	*	*		*					21
Maffulli ¹¹⁹ (2001)	No	16	*								20
Majewski ¹²⁰ (2008)	No	28	*	*							17
Mandelbaum ¹²¹ (1995)	No	29	*	*	*		*				14
Marti ¹²² (1983)	No	64	*								4
Martinelli ¹²³ (2000)	No	30	*								7
Mauch ¹²⁴ (2017) ^c	No	42	*			*				*	17
Mavrodontidis ¹²⁵ (2015)	No	11	*								17
Mayer ¹²⁶ (2010) ^e	No	24	*	*	*						17
Mezzarobba ¹³¹ (2012)	No	40	*	*							12
Miyamoto ¹³³ (2017)	No	44	*	*	*						17
Moberg ¹³⁴ (1992)	No	17	*	*							14
Mortensen ¹³⁹ (1992)	No	57	*								18
Mortensen ¹³⁸ (1999)	No	71	*	*							20
Motta ¹⁴⁰ (1997)	No	71	*	*							14
Mukundan ¹⁴¹ (2010)	No	21	*								17
Mullaney ¹⁴² (2006)	No	20	*	*							17
Ocguder ¹⁴⁶ (2011)	No	41	*	*		*					17
Ozer ¹⁵¹ (2016)	No	23	*	*				*			19
Ozkan ¹⁵² (2016)	No	15	*	*							19
Ozkaya ¹⁵³ (2009)	No	25	*	*		*			*	*	19
Peng ¹⁵⁴ (2017)	No	15	*	*	*			*		*	18
Porter ¹⁵⁷ (2014)	No	40	*	*	*		*		*		17
Porter ¹⁵⁸ (2015)	No	51	*	*	*						21
Quagliarella ¹⁵⁹ (2010)	No	51	*								18
Richardson ¹⁶³ (2003)	No	30	*	*	*					*	15
Rozis ¹⁶⁷ (2018)	No	82	*	*	*					*	19
Sandberg ¹⁶⁹ (2015)	No	31	*	*							14
Saper ¹⁷⁰ (2016)	No	82	*	*							11
Saw ¹⁷¹ (1993)	No	19	*	*							14
Saxena ¹⁷² (2011)	No	27	*	*	*						15
Schäfer ¹⁷³ (2002) ^c	No	40	*								18

(continued)

Table A2 (continued)

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Schepull ¹⁷⁴ (2013)	No	35	*	*	*						20
Schepull ¹⁷⁵ (2007)	No	10	*								20
Solveborn ¹⁷⁹ (1994)	No	17	*	*							15
Sorrenti ¹⁸⁰ (2006)	No	64		*			*	*		*	13
Speck ¹⁸¹ (1998)	No	20	*	*							16
Steele ¹⁸² (1993)	No	20	*								21
Strauss ¹⁸³ (2007)	No	52	*			*					19
Suchak ¹⁸⁴ (2008)	Yes	110	*	*						*	24
Tarniță ¹⁸⁶ (2016)	No	15	*	*							9
Tezeren ¹⁸⁷ (2006)	No	24	*	*	*		*			*	19
Troop ¹⁹⁰ (1995)	No	13	*	*							17
Vadala ¹⁹² (2012)	No	80	*								19
Valkering ¹⁹³ (2017)	No	56	*	*							23
Wredmark ²⁰¹ (1992)	No	34	*								17
Yotsumoto ²⁰² (2010)	No	20	*	*	*						18
Zayni ²⁰³ (2017)	No	29	*	*							21
Zell ²⁰⁴ (2000)	No	25	*	*						*	10
Both Nonsurgical and Surgical Management											
Cetti ³¹ (1993)	No	156	*								21
Costa ³⁸ (2006)	No	96	*								21
Ebinesan ⁵³ (2008)	No	63	*	*		*				*	16
Gwynne-Jones ⁶⁸ (2011)	No	363	*	*		*				*	19
Hutchison ⁸² (2015)	No	273	*	*	*						17
Jackson ⁸³ (2013)	No	80	*	*							20
Karaaslan ⁹⁰ (2016)	No	16		*							17
Kearney ⁹³ (2011)	No	49	*	*							19
Lantto ¹⁰³ (2016)	Yes	60	*	*							22
Lill ¹¹⁰ (1996) ^c	No	57	*			*	*		*	*	11
Lim ¹¹¹ (2018)	No	132	*	*		*				*	19
Lorkowski ¹¹³ (2007)	No	94								*	13
Maffulli ¹¹⁵ (2017)	No	26		*	*					*	18
Miller ¹³² (2005)	No	111	*								18
Moller ¹³⁷ (2001)	Yes	112	*	*							21
Nilsson-Helander ¹⁴⁴ (2010)	Yes	97	*	*							22
Olsson ¹⁵⁰ (2013)	Yes	100	*	*	*	*	*	*		*	22
Renninger ¹⁶² (2016)	No	57	*	*	*		*	*			20
Richter ¹⁶⁴ (1994) ^c	No	32	*								14
Richter ¹⁶⁵ (1997) ^c	No	55	*			*	*		*	*	17
Thermann ¹⁸⁹ (1995) ^c	Yes	50	*			*	*	*		*	17
Twaddle ¹⁹¹ (2007)	No	50	*	*							22
Weber ¹⁹⁶ (2003)	No	47	*	*	*	*	*		*		19
Willits ¹⁹⁹ (2010)	No	144	*	*	*		*	*	*		22
Knobe ⁹⁷ (2015)	No	64	*	*							21

^aThe quality score was determined using the modified Downs & Black^{79,98,145} checklist, in which 26 or above indicates excellent, 20-25 good, 15-19 fair, and 14 or less poor quality. ROM, range of motion.

^bIn Danish.

^cIn German.

^dIn Spanish.

^eIn Portuguese.

TABLE A3
Summary of Outcomes in All Included Studies

First Author (Year)	Outcome Type							Time of Outcome Assessment, mo					
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)					
									≤3	4-6	7-12	>1-5	>5
Nonsurgical Management													
Aujla ¹² (2018)		*	*	*								*	
Aujla ¹¹ (2016)		*	*	*								*	
Barfod ¹⁴ (2014)	*		*	*	*			Quality of life		*	*		
Dolphin ⁴⁸ (2016)		*	*	*						*			
Ecker ⁵⁴ (2016)	*	*	*	*	*	*	*	Pain, satisfaction, meteosensitivity				*	
Hüfner ⁸¹ (2006)	*	*	*	*	*	*		Pain				*	
Hüfner ⁸⁰ (2002)	*								*		*		
Kaniki ⁸⁹ (2014)	*	*	*				*				*	*	
Korkmaz ⁹⁹ (2015)		*	*	*	*		*			*	*		
McComis ¹²⁷ (1997)	*		*		*		*	Cost of treatment		*		*	
McNair ¹²⁹ (2013)	*			*						*			
Neumayer ¹⁴³ (2010)	*	*	*	*			*	Satisfaction		*	*	*	
Persson ¹⁵⁵ (1979)	*	*	*	*		*		Satisfaction				*	
Petersen ¹⁵⁶ (2002) ^b	*		*	*						*	*		
Reilmann ¹⁶¹ (1996) ^c	*	*	*	*	*			Meteosensitivity, pain, footwear problems			*		
Roberts ¹⁶⁶ (2001)	*	*	*		*							*	
Saleh ¹⁶⁸ (1992)	*		*	*	*			Satisfaction	*	*	*		
Swennergren ¹⁸⁵ (2017)						*		Achilles tendon resting angle	*	*			
Vavra-Hadziahmetovic ¹⁹⁴ (2000)	*	*		*		*	*	Thompson, Simmond and Matles signs; pain	*				
Walz ¹⁹⁵ (1993)	*		*		*	*			*	*			
Surgical Management													
Agres ¹ (2018)	*					*				*			
Aisaiding ² (2018)	*	*	*	*	*	*				*	*	*	
Aktas ³ (2007)	*	*	*	*	*		*	Pain				*	
Al-Mouazzen ⁴ (2015)		*	*	*	*			Satisfaction	*	*	*		
Alviti ⁵ (2017)	*												
Aoki ⁸ (1998)	*		*		*			Time from surgery to weightbearing/ heel rising	*	*			
Aspenberg ⁹ (2015)						*			*	*			
Assal ¹⁰ (2002)	*	*	*		*		*					*	
Baumfeld ¹⁶ (2019)	*	*		*	*		*	Satisfaction				*	
Bevoni ¹⁷ (2014)	*	*	*	*	*		*					*	
Bhattacharyya ¹⁸ (2009)	*	*						Pain/stiffness, readmission to hospital, length of hospital stay, pain medication	*	*	*		
Buchgraber ²⁵ (1997)	*	*	*	*								*	
Calder ²⁶ (2005)	*	*	*	*			*		*	*	*		
Carmont ²⁷ (2015)	*	*	*	*				Achilles tendon resting angle	*	*	*		
Carmont ²⁸ (2017)	*			*	*			Achilles tendon resting angle, calf squeeze test	*	*	*		
Ceccarelli ³⁰ (2007)	*	*	*				*					*	
Cetti ³² (1994)	*	*	*	*		*		Satisfaction	*	*	*		
Chandrakant ³³ (2012)		*	*				*	Time to plateau in improvement				*	

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type							Time of Outcome Assessment, mo						
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)						
Chen ³⁴ (2015)	*	*	*				*	Operative time, scar length			*	*		
Chiu ³⁵ (2013)	*	*	*				*		*	*		*		
Chmielnicki ³⁶ (2016) ^c		*	*									*		
Costa ³⁹ (2003)	*	*	*				*		*	*	*			
Čretnik ⁴¹ (2004)	*	*	*	*			*	Holz score, satisfaction				*		
De Carli ⁴² (2016)	*	*	*	*	*	*		Pain	*	*		*		
De la Fuente ⁴³ (2016)	*	*	*	*				Pain, pain medication	*					
De la Fuente ⁴⁴ (2016)	*	*	*	*		*			*					
Delgado-Brambila ⁴⁵ (2012) ^d				*	*			Number of physical therapy visits		*				
Ding ⁴⁶ (2012)	*	*	*				*	Scar length				*		
Don ⁵⁰ (2007)	*			*					*	*	*	*	*	
Doral ⁵¹ (2013)	*			*	*							*		
Dos Santos Gomes ⁵² (1998) ^e	*				*	*		Pain, edema in Achilles tendon area			*			
Fernández-Fairén ⁵⁷ (1997)	*	*	*	*			*	Stiffness				*		
Fitzgibbons ⁵⁸ (1993)	*	*	*		*							*		
Gaiani ⁶⁰ (2012)		*	*	*			*	Satisfaction						
Garrido ⁶² (2010)	*	*	*	*	*		*	Satisfaction				*		
Geremia ⁶³ (2015)	*					*						*		
Gigante ⁶⁴ (2008)	*	*	*	*		*		Operative time		*	*			
Gorschewsky ⁶⁵ (2004)	*	*	*		*			Satisfaction			*			
Gorschewsky ⁶⁶ (1999)	*	*	*		*			Length of hospitalization, operative time, time to full weightbearing, wound healing, satisfaction			*			
Groetelaers ⁶⁷ (2014)	*	*	*	*	*			Satisfaction, Achilles tendon repair score	*	*	*			
Heikkinen ⁷² (2016)	*	*	*	*		*	*		*		*	*	*	
Henríquez ⁷³ (2012)	*	*	*		*			Cosmesis, length of scar				*		
Holmenschlager ⁷⁵ (2002) ^c	*	*	*	*	*	*	*					*		
Horter ⁷⁶ (2007) ^c		*	*									*		
Hrnack ⁷⁷ (2012)	*	*					*					*		
Jacob ⁸⁴ (2007)	*	*	*		*			Pain, satisfaction				*		
Jallageas ⁸⁵ (2013)	*	*	*	*	*		*	Number of physical therapy sessions, pain				*		
Jielile ⁸⁶ (2012)	*	*	*	*	*	*			*	*		*		
Kangas ⁸⁸ (2003)	*	*	*			*	*		*	*		*	*	
Karabinas ⁹¹ (2014)	*	*	*	*	*		*	Satisfaction, wound healing, Thompson test				*		
Kauranen ⁹² (2002)	*			*				Satisfaction	*	*				
Keller ⁹⁴ (2014)	*	*	*	*	*		*	Satisfaction				*		
Kerkhoffs ⁹⁵ (2002)		*	*	*	*			Length of hospital stay, satisfaction					*	

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)					
									≤3	4-6	7-12	>1-5	>5
Kim ⁹⁶ (2017)	*			*	*		*	Time until able to do single heel-raise				*	
Kuskucu ¹⁰⁰ (2005)	*	*	*		*		*		*	*			*
Lacoste ¹⁰¹ (2012)	*	*	*		*			Socioeconomic and global satisfaction			*		*
Lansdaal ¹⁰² (2007)		*	*		*		*	Operative time			*		
Lapidus ¹⁰⁶ (2007)		*	*						*				
Lee ¹⁰⁷ (2008)	*	*	*	*	*		*	Pain	*	*	*	*	*
Leppilahti ¹⁰⁸ (2000)	*					*							*
Li ¹⁰⁹ (2017)	*	*	*	*		*	*	Satisfaction, pain		*	*		
Lonzarić ¹¹² (2017)	*	*	*		*			Number of physical therapy/clinic sessions, duration of immobilization, duration of crutch use	*	*			
Maffulli ¹¹⁶ (2010)	*	*	*	*	*			Time to full weightbearing					*
Maffulli ¹¹⁷ (2003)	*	*	*	*	*	*		Number of clinic/physical therapy sessions, Boyden scale, satisfaction, footwear restrictions, time to full weightbearing					*
Maffulli ¹¹⁹ (2001)	*	*	*			*		Boyden scale					*
Majewski ¹²⁰ (2008)	*			*	*			Hannover score, satisfaction			*		
Mandelbaum ¹²¹ (1995)	*	*	*		*				*	*	*		
Marti ¹²² (1983)	*	*	*		*							*	
Martinelli ¹²³ (2000)	*		*		*	*							*
Mauch ¹²⁴ (2017) ^c	*									*			
Mavrodontidis ¹²⁵ (2015)	*	*	*	*	*	*		Pain, satisfaction					*
Mayer ¹²⁶ (2010) ^e	*								*				
Mezzarobba ¹³¹ (2012)	*					*						*	
Miyamoto ¹³³ (2017)	*	*	*		*	*	*	Time until able to perform heel-rises	*	*			*
Moberg ¹³⁴ (1992)	*										*		
Mortensen ¹³⁹ (1992)	*	*	*	*	*	*		Satisfaction	*		*		
Mortensen ¹³⁸ (1999)	*	*	*	*	*	*		Whether they had physical therapy, pain, satisfaction	*			*	
Motta ¹⁴⁰ (1997)	*	*	*		*	*		Length of hospital stay	*		*	*	
Mukundan ¹⁴¹ (2010)	*	*			*		*				*		
Mullaney ¹⁴² (2006)	*												*
Ocguder ¹⁴⁶ (2011)	*	*	*	*	*		*	Operative time, pain					*
Ozer ¹⁵¹ (2016)	*	*			*		*				*		

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	≤3	4-6	7-12	>1-5	>5
Ozkan ¹⁵² (2016)	*	*	*										*
Ozkaya ¹⁵³ (2009)	*	*	*		*		*						*
Peng ¹⁵⁴ (2017)	*			*		*				*			
Porter ¹⁵⁷ (2014)	*			*									*
Porter ¹⁵⁸ (2015)	*	*		*	*						*		
Quagliarella ¹⁵⁹ (2010)	*							Hannover score					*
Richardson ¹⁶³ (2003)	*	*	*	*	*		*	Footwear restrictions, satisfaction, pain					*
Rozis ¹⁶⁷ (2018)	*	*	*	*	*		*					*	
Sandberg ¹⁶⁹ (2015)	*					*			*		*		
Saper ¹⁷⁰ (2016)		*	*								*		
Saw ¹⁷¹ (1993)	*	*	*		*								*
Saxena ¹⁷² (2011)					*								
Schäfer ¹⁷³ (2002) ^c	*	*	*		*	*	*	Length of time using crutches, special shoe and night splint		*	*		
Schepull ¹⁷⁴ (2013)	*		*	*		*			*	*	*		
Schepull ¹⁷⁵ (2007)	*	*		*	*	*	*	Pain	*	*	*		
Solveborn ¹⁷⁹ (1994)	*	*	*	*	*	*		Satisfaction	*		*		
Sorrenti ¹⁸⁰ (2006)		*	*		*			Time to activities of daily living					*
Speck ¹⁸¹ (1998)	*	*	*	*	*	*		Achilles tendon evaluation score (created by the authors), pain, satisfaction	*	*	*		
Steele ¹⁸² (1993)	*	*	*										*
Strauss ¹⁸³ (2007)		*	*	*	*		*	Pain, satisfaction, footwear restrictions, Boyden scale					*
Suchak ¹⁸⁴ (2008)	*	*	*	*				Number of steps	*	*	*		
Tarnița ¹⁸⁶ (2016)	*	*						Aesthetics of surgical site			*		
Tezeren ¹⁸⁷ (2006)	*	*	*	*		*		Operative time, duration of hospital stay, scar adhesions, footwear problems, satisfaction, pain					*
Troop ¹⁹⁰ (1995)	*	*	*	*	*			Satisfaction					*
Vadala ¹⁹² (2012)	*	*	*	*	*		*	Hannover score					*
Valkering ¹⁹³ (2017)	*	*	*			*			*	*	*		
Wredmark ²⁰¹ (1992)	*	*	*		*	*					*		
Yotsumoto ²⁰² (2010)	*	*		*	*	*	*	Time to walk without pain or fear, time to normal walk, double- and single-legged heel-rises	*	*			
Zayni ²⁰³ (2017)	*	*		*	*	*	*	Satisfaction					*
Zell ²⁰⁴ (2000)	*	*	*		*				*	*			

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type							Survey- Based Functional Outcome	Other General Outcome (Description)	Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties								
							≤3			4-6	7-12	>1-5	>5	
Both Nonsurgical and Surgical Management														
Cetti ³¹ (1993)	*	*	*	*					Length of hospital stay, pain		*	*		
Costa ³⁸ (2006)	*	*	*	*					Time to activities (sport, walking, stair climbing, work)	*	*	*		
Ebinesan ⁵³ (2008)		*	*						Operative time, length of hospital stay, cost		*			
Gwynne-Jones ⁶⁸ (2011)		*	*						Operative time					
Hutchison ⁸² (2015)		*	*	*					Achilles tendon repair score, cost		*	*		
Jackson ⁸³ (2013)		*	*	*	*									
Karaaslan ⁹⁰ (2016)	*	*	*	*	*				Satisfaction				*	
Kearney ⁹³ (2011)				*					Completion rates	*	*	*		
Lantto ¹⁰³ (2016)	*	*	*	*		*	*	*		*	*		*	
Lill ¹¹⁰ (1996) ^c	*	*	*		*	*	*	*	Length of hospital stay				*	
Lim ¹¹¹ (2018)			*	*										*
Lorkowski ¹¹³ (2007)	*	*	*	*			*	*	Pain				*	
Maffulli ¹¹⁵ (2017)	*	*		*	*	*	*	*	Satisfaction				*	
Miller ¹³² (2005)		*	*	*	*				Pain, satisfaction					*
Moller ¹³⁷ (2001)	*	*	*	*	*	*	*		Pain, satisfaction	*	*	*	*	
Nilsson-Helander ¹⁴⁴ (2010)	*	*	*	*							*	*		
Olsson ¹⁵⁰ (2013)	*	*	*	*						*	*	*		
Renninger ¹⁶² (2016)		*	*		*							*		
Richter ¹⁶⁴ (1994) ^c	*		*	*	*						*			
Richter ¹⁶⁵ (1997) ^c	*	*	*	*	*	*	*		Pain				*	
Thermann ¹⁸⁹ (1995) ^c	*	*	*	*	*	*	*		Author-developed score, pain, satisfaction	*	*	*	*	
Twaddle ¹⁹¹ (2007)	*		*	*					Squeeze test	*	*	*		
Weber ¹⁹⁶ (2003)	*	*	*	*	*		*	*	Length of hospital stay, pain, time to discontinuation of crutch use, satisfaction		*		*	
Willits ¹⁹⁹ (2010)	*	*	*				*	*				*	*	
Knobe ⁹⁷ (2015)	*	*	*	*	*	*	*	*	Satisfaction, pain				*	

^aPROs, patient-reported outcomes.^bIn Danish.^cIn German.^dIn Spanish.^eIn Portuguese.