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Accelerated rehabilitation following Achilles tendon repair after acute rupture – Development of an evidence-based treatment protocol

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ABSTRACT

The acute rupture of the Achilles tendon is a protracted injury. Surgery is only the beginning of a long rehabilitation period. Therefore, the rehabilitation protocol is an integral aspect to restore the pre-injury activity level. Despite several trials available comparing different treatment regimes, there is still no consensus regarding the optimal protocol. Consequently, the aim of our study was to systematically search the evidence available and define a precise rehabilitation programme after operative repair of acute Achilles tendon rupture based on the trials with the highest level of evidence.

We performed a systematic literature search in Medline, Embase and Cochrane library. We identified twelve randomized controlled trials comparing different treatment regimes after operative repair of the Achilles tendon.

Five trials compared full to non weight bearing, all applying immobilization in equinus. Immediate full weight bearing led to significant higher patient satisfaction, earlier ambulation and return to pre-injury activity. Four trials compared early ankle mobilization to immobilization. All trials found mobilization to be superior as it shortens time to return to work and sports significantly. Three trials compared the combination of full weight bearing and early ankle mobilization to immobilization. This combination was most beneficial. Patients showed significantly higher satisfaction, less use of rehabilitation resources, earlier return to pre-injury activities and further demonstrated significantly increased calf muscle strength, reduced atrophy and tendon elongation. No study found an increased rerupture rate for the more progressive treatment.

In conclusion, the rehabilitation protocol after Achilles tendon repair should allow immediate full weight bearing. After the second postoperative week controlled ankle mobilization by free plantar flexion and limited dorsiflexion at 0° should be applied.

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Introduction

The acute rupture of the Achilles tendon (ATR) is a protracted injury as the operative repair only marks the beginning of a long recovery period. Postsurgical rehabilitation is an important aspect in the treatment of these injuries aiming for an early restoration of the pre-injury activity level, without increasing the risk of rerupture or tendon elongation. By now, early weight bearing is widely accepted [1,2]. Currently, there is increasing evidence for even more progressive rehabilitation regimes [3]. Despite the increasing number of RCTs and reviews available, there is still no consensus regarding the most preferable protocol. Furthermore, the evidence available is regularly neglected [4]. In 2010, the American Academy of Orthopaedic Surgeons published the only clinical guidelines, recommending immediate postoperative weight bearing immobilizing the ankle in an orthesis [5]. Since then, two reviews analyzed the current evidence regarding the rehabilitation after ATR [6,7]. Although documenting the superiority of early weight bearing and early ankle mobilization, both come short to suggest a clear treatment recommendation. Consequently, the aim of our study was to systematically search the evidence available and define a precise rehabilitation programme after operative repair of acute ATR based on the trials with the highest level of evidence.

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Materials and methods

Search strategy

The database search was performed on September 30th 2013 in Medline, Embase and the Cochrane Collaboration library. Medline and Embase were searched from inception to September 2013 using the text words "Achilles", "tendon", "rupture" for English and German articles. The terms were combined using a Boolean AND operator. The Cochrane library was searched for the text word "Achilles tendon". Two authors (MB, HP) independently reviewed all citations with regard to the inclusion criteria described below. First all titles were reviewed and studies not meeting the inclusion criteria were excluded. Abstracts of the remaining studies were independently reviewed accordingly. Studies missing the defined inclusion criteria were again excluded. Thereafter, the full text of all remaining articles was retrieved and also independently reviewed. Again, only articles meeting the PICOS criteria were selected. Furthermore, the reference lists of all eligible full text articles were hand-searched to ensure that no relevant studies were missed after the database search. Differences were resolved by discussion. The detailed results of the literature search are shown in Fig. 1.

Eligibility criteria

Only studies evaluating acute, isolated ruptures of the Achilles tendon were included. An acute rupture was defined to be less than 14 days old [8]. In order to guarantee the highest comparability only studies using the same operative intervention were selected. Open surgery was defined as intervention, as the trials with the highest level of evidence available, all applied this procedure and no RCT used percutaneous surgery. We identified all trials comparing different rehabilitation protocols following surgical Achilles tendon repair. The outcome parameters had to include patient satisfaction, functional assessments, time to return to work/sports, tendon elongation, reruptures or complications. Only studies with the highest level of evidence were selected. The level of evidence was assessed independently by two of the authors in accordance to the level-of-evidence rating system introduced by Wright et al. [9] Disagreements were resolved by discussion.

Participants:	Patients with an acute, isolated Achilles tendon rupture
Intervention:	Open operative suture of the Achilles tendon
Comparison:	Different postoperative treatment protocols
Outcomes:	Patient satisfaction, functional assessment, time to return to work/sports, tendon elongation, rerupture, complication
Study design:	Randomized controlled trial

Quality assessment

In order to rank the included studies due to their methodological quality a modified version of the original Coleman Methodology

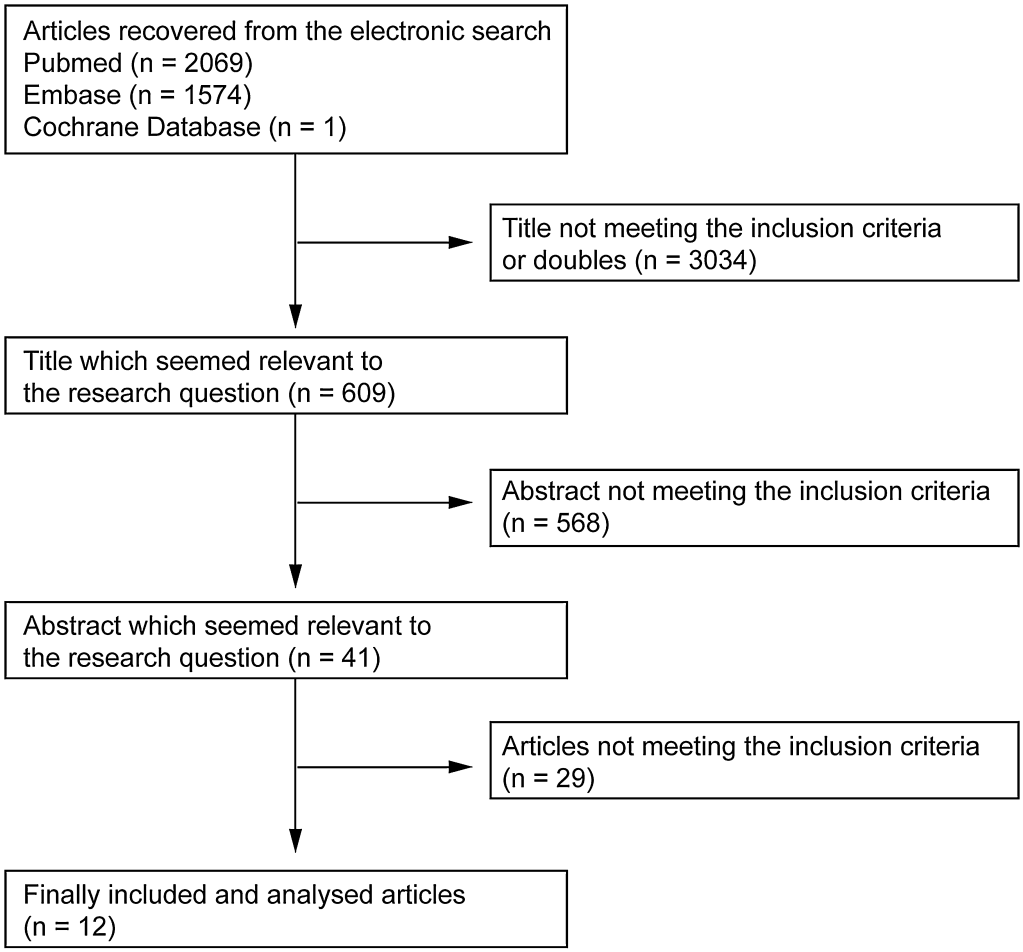

Fig. 1. Flow chart of study selection.

Score (CMS) was used. Coleman et al. initially introduced the CMS to critically assess the methodological deficiency of clinical studies comparing different surgical procedures of patellar tendinopathy [10]. The original score includes numerous criteria, which are scored and added to a maximum of 100 points. The maximum of 100 points indicates a methodologically well-performed study avoiding bias due to confounding factors. According to our study objectives we modified the CMS by replacing several of the original criteria by different measures identified to be important for evaluating the quality of the included studies due to our specific question. Each study was scored to give a total modified CMS between 0 and 100. Two reviewers independently scored the 12 studies selected. The modified CMS score for each study is listed in Table 1.

Results

In total, twelve trials met the inclusion criteria, all performing open surgery. No RCT compared different rehabilitation protocols following percutaneous surgery. The detailed results of the literature search are shown in Fig. 1. For a more critical appraisal we analyzed the two key components of rehabilitation, namely weight bearing and mobilization, separately. A description of all included trials is presented in Table 1.

Full weight bearing (FWB) vs. non weight bearing (NWB)

If not stated differently FWB means immediate FWB with the ankle immobilized in different positions. Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or sports. No rerupture occurred in either group.

Costa et al. demonstrated in 2003, that patients treated with FWB return to sports two months earlier [13]. Furthermore, calf muscle strength measured by the Kincom system and range of motion were increased non-significantly when compared to NWB. In both groups no reruptures were observed.

In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15], calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. Two reruptures were observed for FWB within 12 months, while one paraesthesiae and ATR of the contralateral side was observed for NWB.

Mafulli et al. showed that FWB significantly reduced the time with crutches, number of physiotherapy sessions and the time to return to sports [16]. In addition, FWB led to a higher patient satisfaction measured by 4 point scale introduced by Boyden et al. [17] and better results of the VISA-A [18], although these results were not significantly different. No differences were found for tendon thickness measured by high-resolution real time ultrasound, muscle atrophy assessed by calf muscle circumference and muscle function.

Kerkhoffs et al. treated all patients with a BKC for one week followed by either partial weight bearing or NWB [19]. Patients allowed to bear weight had a significantly shorter hospital stay and time to return to sports. No significant differences were found for the Rupp Score evaluating pain and patient satisfaction. One rerupture was reported in the non weight bearing group.

Early ankle mobilization (EM) vs. immobilization (IM)

If not stated differently EM means immediate free plantar flexion of the ankle with restriction of dorsiflexion at 0°.

Kangas et al. present the same patient collective two times, evaluating different outcome measures when comparing EM to IM [20,21]. Consequently, in the following the two studies will be treated as one. FWB was allowed after three weeks in both groups. No significant differences could be detected for isokinetic and isometric calf muscle function, tendon elongation or pain level assessed by the visual analogue scale – although all in favour of EM [22]. The Achilles Rupture Performance Score did not reveal differences between both groups. One rerupture occurred for EM and two for IM.

Kauranen et al. again allowed FWB after three weeks in both groups [23]. The main outcome parameter was motor performance measured by reaction time, speed of movement and tapping, as well as coordination (lateral and ap). The only significant difference detected was for lateral coordination after 12 weeks only, for IM. Complications, number of reruptures or time to return to work or sports are not reported.

Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumference) and tendon elongation (radiographic markers) was comparable. There were two reruptures following IM and one rerupture following EM.

Combined functional treatment (CFT) vs. immobilization (IM)

In the following, CFT will be considered the combination of immediate FWB and free plantar flexion of the ankle with restriction of the dorsiflexion at 0° after 2 weeks.

Mafulli et al. reported significantly fewer outpatient visits, less physiotherapy, higher patient satisfaction and a shorter time to return to work/sport for CFT [25]. Regarding calf circumference, isometric strength and VISA-A score the results, all in favour of the treatment group, did not reach a level of significance.

Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–20° immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. Furthermore, the time to return to work was significantly prolonged for IM (53.4 days) compared to 20.2 days for CFT. One rerupture was noted for CFT and two for IM.

Shepull et al. performed CFT using a special pedal training twice a day with increasing resistance (maximum of 225 N) [27]. Primary outcome parameters were the mechanical and elastic tendon properties, calculated by Roentgen Stereophotogrammetric

Table 1
Characteristics of the included studies; ATRS: Achilles tendon Total Rupture Score, BKC: below knee cast, CFT: combined functional treatment, d: days, EM: early mobilization, exl.: excluded, FWB: full weight bearing, m: months, NWB: non weight bearing, PWB: partial weight bearing, RAND-36: RAND 36-item health inventory, ROM: range of motion, RTS: return to sports, RTW: return to work, VISA-A: Victorian Institute of Sports Assessment for Achilles tendinopathy, w: weeks, $^{*}p < 0.01$, $^{**}p < 0.001$.

Reference	Intervention (number of tendons)	Rehabilitation protocol	Mean Follow-up (m)	Results non significant	Results significant	Return to work (RTW) Return to sports (RTS)	Rerupture (%)	Complications (%)	Conclusion	CMS
Suchak et al. [11]	Full weight bearing (54)	0–2 w: BKC, NWB, 3–6 w: orthesis (20° to 0° in 3 w), FWB	6	ROM Calf circumference Calf muscle strength	FWB: ↑ RAND-36 * (6 w) ↑ social functioning* (6 m) ↑ median number of steps* (6 w)	6 m – 67% RTS	None	None	FWB improves early quality of life and activity level	78
	Non weigth bearing (55)	0–2 w: BKC, NWB 3–6 w: orthesis (20° to 0° in 3 w), NWB				6 m – 63% RTS		1 thrombosis (2%) 1 deep infection (2%)		
Costa et al. [13]	Full weight bearing (23)	0–8 w: orthesis (3 > 2 > 1 > 0 heel wedges/2 w), FWB	12	FWB: ↑ ROM ↑ calf muscle strength ↑ health questionnaire	None	Normal walking 12.5 w* normal stair climbing 13 w*	2 (8%)	None	FWB reduces time to return to normal activity and improves fuctional outcome	84
	Non weigth bearing (25)	0–8 w: BKC natural equinus to 0° in 2 w intervals, NWB				Normal walking 18 w Normal stair climbing 22 w	None	1 paraesthesiae (4%) ATR contralateral (4%)		
Costa et al. [14]	Full weight bearing (9)	0–8 w: orthesis (3 > 2 > 1 > 0 heel wedges/2 w), FWB	12	FWB: ↑ calf muscle strength ↑ ROM ↑ tendon diameter	None	RTS 6.0 m	None	None	FWB reduces time to return to sports, calf muscle power loss and does not increase rate of rerupture	62
	Non weigth bearing (11)	0–8 w: BKC natural equinus to 0° in 2 w intervals, NWB				RTS 8.0 m				
Maffulli et al. [16]	Full weight bearing (28)	0–2 w: BKC (natural equinus), FWB 3–6 w: BKC (0°), FWB	31	FWB: ↑ calf circumference ↑ isometric strength ↑ patient satisfaction ↑VISA-A	FWB: ↓ outpatient visitis* ↓ time with crutches* ↓ physiotherapy*	RTS 5.2 m*	None	None	FWB shortens rehabilitation and time to return to sports; FWB improves patient satisfaction and muscle function	95
	Non weigth bearing (28)	0–2 w: BKC (full equinus), NWB 3–4 w: BKC (mid equinus), NWB 5–6 w: BKC (0°), FWB				RTS 6.1 m				

Table 1 (*Continued*)

Reference	Intervention (number of tendons)	Rehabilitation protocol	Mean Follow-up (m)	Results non significant	Results significant	Return to work (RTW) Return to sports (RTS)	Rerupture (%)	Complications (%)	Conclusion	CMS
Kerkhoffs et al. [19]	Partial weight bearing (16)	0–1 w: BKC (plantar flexion), NWB 2–8 w: semi rigid wrap (0°), PWB	80	PWB: ↑ functional and pain questionnaire	PWB: ↓ hospital stay*	RTS: 56.7 d*	None	None	PWB reduces hospital stay and time to return to sports without increasing the risk of rerupture	57
	Non weight bearing (23)	0–1 w: BKC (plantar flexion), NWB 2–8 w: BKC (0°), NWB				RTS: 72.8 d	1 (4%)			
Kangas et al. [20] Kangas et al. [21]	Early mobilization (25)	0–3 w: free plantar flexion – restricted dorsiflexion at 0°, NWB 4–6 w: free plantar flexion – restricted dorsiflexion at 0°, FWB	15	EM: ↑ calf muscle strength ↓ tendon elongation	None	Not reported	1 (4%)	None	Tendon elongation is less after EM; EM does not increase the risk of rerupture	77
	Immobilization (25)	0–3 w: BKC (0°), NWB 4–6 w: BKC (0°), FWB					2 (8%)	1 deep infection (4%)		
Kauranen et al. [23]	Early mobilization (15)	0–3 w: free plantar flexion – restricted dorsiflexion at 0°, NWB 4–6 w: free plantar flexion – restricted dorsiflexion at 0°, FWB	12	Reaction time Speed of movement Coordination	None	Not reported	Not reported	Not reported	EM does not improve motor performance significantly	59
	Immobilization (15)	0–3 w: BKC (0°), NWB 4–6 w: BKC (0°), FWB								
Mortensen et al. [24]	Early mobilization (31)	0–2 w: BKC (natural equinus), NWB 3–4 w: passive plantar flexion – active dorsiflexion to 0°, NWB 5–6 w: orthesis (fixed 0°), FWB	16	EM: ↑ subjective satisfaction ↓ calf atrophy	EM: ↓ adhesions* ↑ ROM* (6+12 w) ↑ tendon elongation (only 6 w)**	RTW 43 d* RTS 4.0 m** Preinjury level 6.0 m**	1 (3%)	1 deep infection (3%)	EM shortens time to return to work, sports and preinjury level and is not detrimental	85
	Immobilization (30)	0–6 w: BKC (natural equinus), NWB 7–8 w: BKC (0°), NWB				RTW 68 d RTS 7.5 m Preinjury level 9.0 m	2 (6%)	None		

Table 1 (*Continued*)

Reference	Intervention (number of tendons)	Rehabilitation protocol	Mean Follow-up (m)	Results non significant	Results significant	Return to work (RTW) Return to sports (RTS)	Rerupture (%)	Complications (%)	Conclusion	CMS
Maffulli et al. [25]	Combined functional treatment (26)	0–2 w: BKC (natural equinus), FWB	21		CFT: ↓ outpatient visits *	RTW 9.2 w*	None	None	CFT significantly reduces time of rehabilitation, improves functional results without increasing the risk of rerupture or elongation	95
		3–6 w: Free plantar flexion – restricted dorsiflexion at 0°, FWB		CFT: ↑ VISA-A	↓ physiotherapy *	RTS 5.1 m*				
				↓ calf atrophy	↑ patient satisfaction *					
				↑ isometric strength						
	Immobilization (27)	0–2 w: BKC (full equinus), NWB				RTW 13.2 w				
		3–4 w: BKC (mid equinus), NWB				RTS 6.0 m				
		5–6 w: BKC (0°), FWB								
Cetti et al. [26]	Combined functional treatment (30)	0–6 w: free plantar flexion – restricted dorsiflexion at –20°, FWB	12	Tendon thickness	CFT: ↑ patient satisfaction*	RTW: 20.2 d**	1 (3%)	None	CFT significantly enhances patient satisfaction and functional assessments and reduces tendon lengthening	77
					↑ ROM* (6 w) ↓ calf atrophy* ↓ tendon elongation** (12 m)	Preinjury level 80%*				
	Immobilization (30)	0–6 w: BKC (20° plantar flexion), NWB				RTW: 53.4 d	2 (6%)	1 deep infection (3%)		
						Preinjury level 50%				
Schepull et al. [27]	Combined functional treatment (13)	0–2 w: BKC (equinus), FWB	12	CFT: ↑ elastic modulus	CFT: correlation between early elastic modulus and ATRS*	Not reported	1 (exl.)	2 thrombosis (15%)	CFT increases elastic tendon properties but does not increase the risk of rerupture or tendon elongation	81
		3–7 w: orthesis (3 > 2 > 1 heel wedges/w), FWB		↑ ATRS						
				↓ tendon elongation						
	Immobilization (16)	0–3.5 w: BKC (equinus), FWB					None	2 thrombosis (12%)		
		3.5–7 w: BKC (0°), FWB								

Analysis and CT scans. The resulting elastic modulus was 33% higher for CFT. Tendon elongation was assessed by implantation of tantalum markers and was increased in the IM group. The heel raise index and Achilles Tendon Rupture Score were comparable in both groups [28]. One patient in the CFT group suffered a rerupture.

Discussion

Up to now, three meta-analyses explicitly focus on the rehabilitation after acute ATR [3,6,29]. Suchak et al. included six studies until 2004, investigating the effect of early functional treatment in contrast to IM [29]. Main results were significantly better subjective outcome and less minor complications without increasing the rate of rerupture for early functional treatment. The major limitation of this review is that the authors do not illuminate the different aspects of the rehabilitation, but solely differentiate between immobilization and all other treatment regimes. Kearney et al. particularly investigated the effect of immediate FWB. They conclude, that it does not increase the risk of rerupture [3]. Two aspects should be considered: First, in the studies included both operative and non-operative treatment was performed. Second, studies with all levels of evidence were incorporated. Recently, a third review by Huang et al. compared various rehabilitation protocols [6]. The authors conclude that the combination of FWB and EM is superior to IM. This study fails to draw a final conclusion and to suggest a specific postoperative protocol. As a result, there is still no evidence based treatment protocol available. For this reason we here present a precise rehabilitation programme after operative repair of acute ATR based on the trials with the highest level of evidence available.

Full weight bearing (FWB) vs. non weight bearing (NWB)

We identified five RCTs explicitly comparing the effect of FWB to NWB. Three allowed FWB immediately, two started after two weeks. All studies applied immobilization in equinus.

Suchak et al. [11] allowed FWB two weeks postoperatively, reporting significantly higher patient satisfaction for FWB using the RAND-36 score. This is a validated health-related quality-of-life questionnaire but not specifically designed to assess disorders of the Achilles tendon. All functional outcome parameters did not differ significantly. FWB did not lead to a higher rerupture rate; NWB instead was associated with two major complications (thrombosis, deep infection).

Costa et al. performed a study reporting better results all in favour of FWB, while only the time to return to sports reached a level of significance [13]. Based on these results, they performed a RCT enrolling more patients [14]. FWB shortened the time to return to normal walking and stair climbing significantly. Calf muscle strength was increased by FWB, but not significantly. Furthermore, they assessed the range of ankle motion and thereby concluded that FWB does not lead to tendon lengthening. Care must be taken when drawing this conclusion. Finally, the authors reported two reruptures for FWB. They stated that both occurred during activities, which were in breach of the written rehabilitation protocol and reason that careful patient selection is necessary to avoid complications by FWB.

Mafulli et al. found significant faster recovery, meaning less use of rehabilitation resources, earlier return to work and higher satisfaction levels for FWB [16]. Although functional outcome measurements were better in the treatment group, FWB could again not significantly prevent calf muscle atrophy or loss of isometric strength. Next to calf circumference the authors used isometric plantar flexion strength and high-resolution ultrasound in order to assess objectified measures. Furthermore, the questionnaire used was specifically designed for the Achilles tendon [30]. No reruptures in either group were observed.

Kerhoffs et al. did not apply FWB but partial weight bearing instead. PWB significantly reduced hospital stay and allowed patients to return to sports sooner [19]. The only rerupture occurred in the NWB group. Major strength of this study is the follow up period of 80 months in average. This represents the longest follow up among all studies included. Apart from that, Kerkhoffs et al. did not describe their postoperative treatment protocol explicitly. Neither the intervals of equinus-reduction, the protocol for active ankle exercises, patients lost to follow up, nor the term "partial weight bearing" was clearly defined. Furthermore, outcome measurements were mainly subjective parameters and did not include validated outcome measurements.

In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture rate or tendon lengthening. Therefore, the patients should be allowed to bear full weight immediately after the operation.

Early ankle mobilization (EM) vs. immobilization (IM)

We identified four RCTs exclusively comparing the effect of early ankle mobilization to immobilization. While three trials documented free plantar flexion limiting dorsiflexion at 0°, one trial used a sophisticated brace applying the Kleinert traction principle.

Kangas et al. presented 50 patients in both studies [20,21]. When carefully studying the articles one must anticipate that the authors publish different outcome measures of the same patients twice. From our point of view this data cannot be treated as two independent studies and constitutes a major limitation. EM improved calf muscle strength, patient satisfaction and decreased tendon elongation. However, none of these differences did reach significance. Unfortunately, the clinical observers were not blinded to the treatment regime when evaluating the functional outcome parameters. Reruptures were more frequently seen in the IM group.

Kauranen et al. assessed several motor performance aspects [23]. The authors could not identify any significant differences for motor performance. Restrictively, the authors do not include any further outcome parameters. This is a major limitation, as motor performance is highly specific. The interpretation of this data, even in healthy participants, is unclear. Furthermore, the number of patients enrolled is low and the follow up period is short. Apart from this, the authors do not report on any complications, number of reruptures or time to return to work or sports. Therefore, the information of this study is limited.

Mortensen et al. used a brace adopting the Kleinert traction principle allowing 20° of ankle motion [24]. EM led to a significantly earlier return to work and sports. Furthermore, these patients suffered from significantly fewer and less severe adhesions. But, this clinical parameter has to be interpreted carefully as the visual examination for adhesions is a subjective value and the observers were not blinded to the different groups. Range of motion, calf muscle atrophy, plantar flexion strength and rerupture rate showed improved results following EM, but without significance.

In conclusion, EM is superior to IM as it shortens time to work and sports significantly. Moreover, EM does not increase the rerupture rate. Based on these findings, free plantar flexion with restriction of dorsiflexion at 0° should be allowed latest after three weeks.

Combined functional treatment (CFT) vs. immobilization (IM)

How does the combination of full weight bearing and early ankle mobilization (combined functional treatment) affect the outcome after Achilles tendon repair? We identified three RCTs comparing a combined functional treatment to immobilization.

Mafulli et al. showed that patients treated by CFT needed significantly fewer outpatient visits, less physiotherapy and reported a higher subjective satisfaction, as well as shorter time to return to work and sports [25]. Further, this treatment led to higher isometric strength levels and decreased calf atrophy but not significantly. No rerupture occurred in either group. The study contributed by Mafulli et al. has several strengths, such as the large number of patients enrolled (53), the mean follow up of 21 months and the blinded assessment of various well established outcome parameters represented by the highest CMS score of all studies included.

Cetti et al. found that the range of motion, calf atrophy and time to return to work was significantly in favour of CFT [26]. Remarkably, tendon elongation was significantly higher in the IM group. Again, the majority of the functional results were superior for CFT. This study is the first trial documenting these results with a statistical significance. Even though the trial has been published nearly 20 years ago, it is strong in its design, due to the large number of patients enrolled, the objective technique assessing tendon elongation and the other well established outcome parameters used.

The study performed by Shepull et al. evaluated the effect of CFT using a special pedal device [27]. The elastic modulus was higher for CFT, significantly correlating with a better functional outcome. Again, tendon elongation could not be observed in the CFT group in contrast to the IM group. Although patients in the CFT group performed exercises with resistance, rerupture rates did not differ between the two groups. Next to functional outcome parameters and a validated score, the authors used multiple imaging techniques to assess the tendon properties. Nevertheless, the approach regarding the patients lost to follow up is inconsistent as these patients are again included in the final follow up.

Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates, the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both.

Conclusion

We define the following evidence-based rehabilitation protocol. The patients are allowed to bear full weight immediately.

Evidence-based rehabilitation protocol after Achilles tendon repair

	Week 0 - 2	Week 3 - 6	Week 7 -
ROM	None	0° / 0° / 30° DF / PF	Free
Orthesis	Fixed PF at 30°	30° PF to 0°	None
Weight bearing	Full weight bearing		

Fig. 2. Evidence-based accelerated rehabilitation protocol following operative repair of acute Achilles tendon ruptures; DF: dorsiflexion, PF: plantar flexion, ROM: range of motion.

For two weeks the ankle is immobilized in plantar flexion. Starting in week three the patients are encouraged to mobilize the ankle with free plantar flexion and restriction of dorsiflexion at 0°. In Fig. 2 the protocol is depicted in detail. This evidence-based protocol provides quality assurance for the patient on the one hand and confidence for the attending physician on the other.

Limitations

We detected twelve RCTs all following open surgery. When separating the trials according to the different rehabilitation aspects (weight bearing, ankle mobilization and the combination of both) a small number of RCTs results for each subgroup. This might limit the conclusions drawn. Moreover, unfortunately we could not identify any randomized controlled trial following percutaneous surgery, although this has become the treatment of choice. Percutaneous surgery does not increase the rate of rerupture but provides greater patient satisfaction and decreases the complication rate [31]. Up to now, there are several prospective studies comparing the effect of early functional treatment to immobilization after percutaneous repair. Again these studies demonstrate higher patient satisfaction and earlier return to pre-injury activity without an increased rate of reruptures all in favour of functional treatment [8,32,33]. Moreover, several biomechanical cadaver studies investigated the strength of percutaneous techniques in comparison to open repair and found similar results [34,35]. Consequently, we apply the same postoperative protocol following percutaneous repair of ATR. Currently, we validate this protocol in our level 1 trauma centre. Furthermore, one should appreciate that up to date in all studies the more progressive rehabilitation protocol provided superior results without increasing complication rate. Consequently, RCTs evaluating even more accelerated protocols are needed to define the limits of progressive rehabilitation.

Conflict of interest statement

All authors have no financial or personal relationships with other people or organizations that could influence their work to disclose.

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