

ACHILLES TENDON RUPTURE

AN INTERNATIONAL EVIDENCE-BASED APPROACH TO TREATMENT AND REHABILITATION. SURGICAL OR NON-SURGICAL TREATMENT?

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ACHILLES TENDON ANATOMY

The Achilles tendon receives its blood supply from three sites: the musculotendinous junction, the paratenon and distally at the tendon insertion to the bone. The paratenon plays an important role⁴.

Tendons are designed to transfer large forces from muscle to bone and are less able to withstand shear and compression forces than tensile forces. At rest, the tendon fibres display a wavy configuration. This disappears when the tendon is stretched approximately 2%. When the force is released, the tendon fibres resume their wavy appearance. Up to approximately 4% elongation, the tendon will return to its original state after the tension is released. If the tendon is stressed beyond approximately 4% of its length, partial ruptures will occur and at approximately 8% of elongation, a complete rupture will occur (Figure 1). This

means that irreparable changes will occur in the tendon. A stress-strain curve is often presented in the literature when describing the mechanical behaviour of a tendon⁸.

The elasticity of the Achilles tendon is important to store and release energy during the stretch shortening cycle (SSC). A heavy load on the Achilles tendon occurs in activities during which the SSC is used. The SSC is a combination of an eccentric muscle action (with lengthening of the muscle and tendon), followed immediately by a concentric muscle action (shortening of the muscle-tendon complex). The concentric force production is higher when it is preceded by an eccentric muscle action compared with a pure concentric muscle action. This is in part due to the utilisation of the passive elastic components such as the tendon. The larger the cross-sectional area of a tendon, the greater its capacity to

withstand heavy loads before failure. Longer tendons have a greater capacity to elongate before failure compared to shorter tendons⁹.



Re-rupture rate is significantly lower with surgical treatment than with non-surgical treatment





Figure 1: Total rupture of the Achilles tendon. Note how frayed the ends of the torn tendon are.

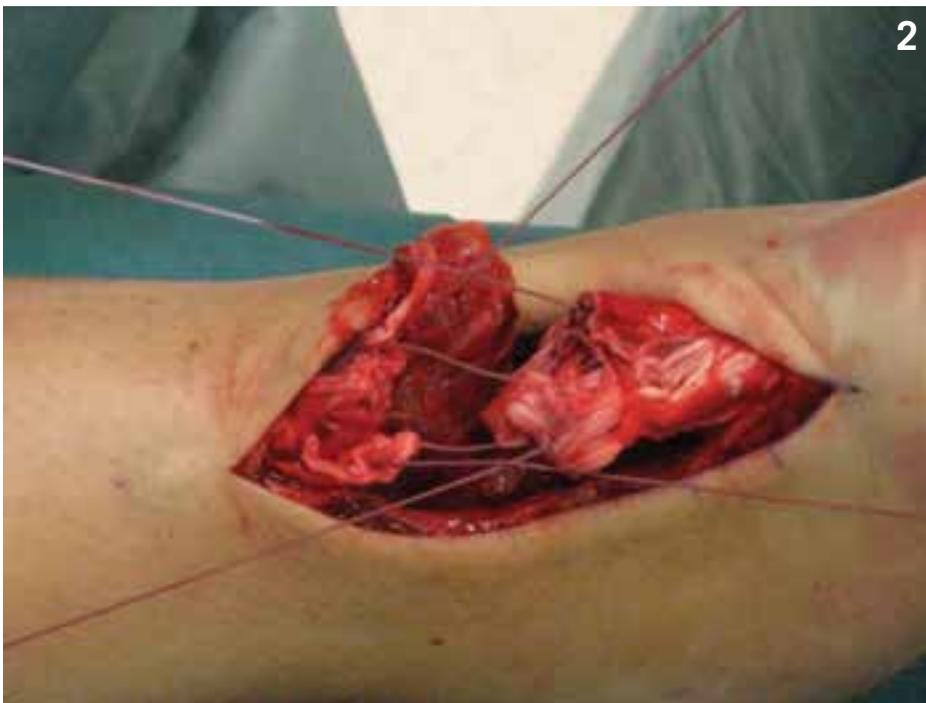


Figure 2: Suture of acute Achilles tendon rupture. Using strong sutures (fibre-wire) the risk of re-rupture is markedly reduced.

In animal studies, the healing tendon has been reported to regain about 50% of its tensile strength and 30% of its energy absorption within 2 weeks after surgery. This indicates that non-surgical treatment with early range of motion and early weight-bearing is, in most cases, safe treatment. The optimal amount of loading that benefits the healing of the tendon but does not cause a re-rupture is, however, still unknown.

SURGICAL OR NON-SURGICAL TREATMENT

The treatment of acute Achilles tendon ruptures may be surgical (open/percutaneous) or non-surgical. In the literature, the main outcome measure when comparing surgical and non-surgical treatments is the risk of a re-rupture^{10,11,14,16} (Figure 2).

The re-rupture rate is significantly lower with surgical treatment (approximately 3%) than with non-surgical treatment (approximately 10 to 13%). A recent meta-analysis including six trials recommended surgical repair. One main problem is the variation in the methodological quality in studies on the treatment of acute Achilles tendon ruptures. There is little consensus with regard to functional recovery from recent studies due to inconsistent assessment systems. The Achilles Tendon Rupture Score was recently published as an instrument to report the results after treatment of Achilles tendon rupture. The score is tested for validity and reliability and has been successfully used in recent studies¹¹.

In a recent meta-analysis, the re-rupture rates were estimated to be 4.3 and 9.7%

TENDON HEALING

After a tendon injury there are three phases of healing: inflammatory, proliferative and remodelling^{10,11,16}.

- **Phase 1: Acute inflammatory phase.** This lasts for up to 1 week after injury. During this phase, inflammatory cells remove the injured tissue.
- **Phase 2: The proliferative phase.** During this phase, type I collagen is produced by fibroblasts to increase tendon strength. After about 4 weeks more than 50% of

the tensile strength of the tissue may be restored. The proliferative phase lasts up to about 4 weeks in most individuals.

- **Phase 3: The remodelling phase.** Here, healing occurs for up to 1.5 years after the original injury. During this phase, the tensile strength, elasticity and structure of the tendon improve. However, there is currently no evidence that the tendon will fully recover its properties, which indicates that there are permanent changes in the tendon.

in surgically and non-surgically treated patients, respectively¹². Compared with non-surgical treatment, surgical treatment can effectively reduce the risk of re-rupture. However, as noted above, surgical treatment increases the likelihood of complications and today, there is no evidence that surgical treatment leads to improved functional recovery.

Percutaneous repair has increased in popularity. Early weight-bearing and mobilisation with or without surgical treatment produced the best result, provided that the tendon ends were in contact⁸.

As has been shown, strong scientific evidence is lacking regarding the optimal treatment for acute Achilles tendon rupture. The outcomes between surgical and non-surgical treatments appear to be comparable, although the re-rupture rate is somewhat higher in the non-surgical group in most studies. A movable brace and/or weight-bearing appear to be preferable to a cast regardless of whether surgery is performed.

POSTOPERATIVE TREATMENT: IMMOBILISATION VS FUNCTIONAL BRACE

In recent studies, patients who had surgical treatment were randomised postoperatively to a rigid cast alone or to a functional brace (Figure 3) after a short period in a rigid cast. An overall lower re-rupture rate in favour of a functional brace was reported. However, there were no significant differences between the treatment groups in any of the studies in terms of complications other than re-rupture rate. Therefore, functional braces appear to be beneficial at least when compared to casting^{10,11,13-15}.

A recent meta-analysis including six randomised studies compared traditional (immobilisation) and early functional postoperative protocols^{5,6,8,9}. In the group using a functional postoperative protocol with early weight-bearing, patients judged their quality of life to be higher than those in the traditional non-weight-bearing group. Patients in the traditional group complained more about scar adhesion and transient sural nerve dysfunction, even though there were no statistically significant differences between the groups. The authors therefore recommended

that larger, well-powered prospective, randomised studies be performed to reach more definite conclusions (this is something that has been repeatedly mentioned in Achilles tendon research during the last 10 years). It is obvious that most treatment studies are hampered by a similar problem i.e. low or marginal power^{8,10,16}.

The treatment regimens in the studies mentioned above were not identical, but all of them still concluded that early mobilisation appears to reduce rehabilitation time and result in a lower re-rupture rate in patients treated surgically. It may also result in faster return to sport, with impact on health economy that should be taken into consideration. It may therefore be argued that early mobilisation and early weight-bearing are probably of major

importance in the treatment of an acute Achilles tendon rupture.

SURGICAL TREATMENT OF CHRONIC ACHILLES TENDON RUPTURE

According to the literature, a 'chronic Achilles tendon rupture' is one that is diagnosed 4 to 6 weeks after injury. The exact timing can be debated, though. The different terms used for these injuries in the literature are 'delayed', 'neglected' and 'chronic ruptures'. For medico-legal reasons, the term 'chronic rupture' is preferable. However, there is no universally accepted time limit defining when an acute rupture turns into a chronic rupture. More than 20% of acute Achilles tendon ruptures are described as 'delayed', because the rupture is unrecognised or misdiagnosed by the



Figure 3: A functional brace.

examiner (doctor's delay) or the patient waits before seeking medical attention (patient's delay). When treating a chronic rupture, most surgeons agree that surgery is the treatment of choice, unless there are obvious contraindications to surgery or the patient has low functional demands⁹.

Even though many different surgical techniques exist, only a few of them have been validated scientifically and there is an obvious lack of evidence-based guidelines for the selection of the optimal surgical technique for chronic Achilles tendon ruptures.

The repair of a chronic rupture or a re-rupture is associated with an increased risk of complications such as infection and delayed wound healing. But, it is difficult to draw any definite conclusions in terms of the functional outcome of the different

surgical techniques presented in the literature, because of the wide variation in study design, postoperative regimens and end-points. There are no comparative studies when it comes to comparing different surgical techniques for the treatment of chronic ruptures.

The surgical techniques for repair of chronic Achilles tendon ruptures can be divided into different categories:

- The V-Y technique.
- Local tissue augmentation.
- Turn-down flaps.
- Tendon transfer.
- Free tissue transfer.
- Use of synthetic material.

Several different turn-down flaps have been used to bridge the tendon gap. A recent study has shown good results after free flap transfer of the gastrocnemius aponeurosis.

An open technique is usually recommended for chronic ruptures¹².

THROMBOPROPHYLAXIS

Without thromboprophylaxis, the incidence of deep venous thrombosis (DVT) is 40 to 80% and fatal pulmonary embolism 1 to 5% following major orthopaedic surgery. The need for thrombosis prevention has been generally agreed upon when major orthopaedic surgery is undertaken and standardised thromboprophylaxis regimens are usually implemented.

However, for patients treated for so-called 'minor' lower leg injuries, such as an Achilles tendon rupture, no consensus exists with regard to the advantage of thromboprophylaxis. Only a few studies have reported on the risk of developing symptomatic thromboembolism after

WHAT IS KNOWN?

Aetiology

The aetiology of Achilles tendon ruptures is still not well-known. Two theories have been discussed in recent studies: the degenerative and the mechanical. Some factors suggested to be linked to Achilles tendon rupture are aging of the tendon, vascular impairments and lifestyle factors^{1,2}.

Diagnosis

Additional ultrasonography or MRI can, on few occasions, be useful for verifying the diagnosis and planning the surgical procedure. However, additional investigations should not replace a thorough clinical investigation.

Functional bracing vs casting

An additional functional brace (Figure 3) rather than a cast has been shown to be beneficial in terms of the risk of re-rupture and functional recovery. Limited information is, however, available on the effects of a functional brace, especially in combination with non-surgical treatment.

Surgical vs non-surgical treatment

There is still no consensus as to the best treatment. Surgery is probably most commonly used and appears to result in less risk of a re-rupture. The limitations of surgical treatment include a significantly higher risk of infections, adhesions and other wound-related problems compared with non-surgical treatment. Most elite athletes prefer

surgical treatment. The surgical techniques described in the literature differ considerably, although end-to-end suture, possibly with local augmentation, dominate. Tendon transfer is not recommended for the treatment of acute total Achilles tendon rupture. Compared with non-surgical treatment, surgical treatment can effectively reduce the risk of re-rupture (it may be debated if this is the most important primary variable in studies, instead functional outcome should be increasingly considered). However, surgical treatment increases the likelihood of complications. Today, there is no evidence that surgical treatment leads to improved functional recovery⁷. Studies are limited in size and the varying outcome measurements make comparisons difficult. On the other hand, there is general agreement that surgical treatment is the treatment of choice for a chronic rupture or a re-rupture^{3,7,8}.

Rehabilitation

The optimal rehabilitation is not known and most patients treated for Achilles tendon ruptures still have functional deficits 1 or 2 year after the injury, regardless of whether the treatment is surgical or non-surgical. Until now, no injury-specific, patient-reported scores have been available to evaluate the best rehabilitation protocol after the treatment of Achilles tendon rupture. Improved acute phase treatment e.g. the rehabilitation protocol during the first 3 months after injury, is probably of importance^{5,6,8}.

an acute Achilles tendon rupture. The results varied from a benefit from thromboprophylaxis to no benefit at all. Because the accuracy of a clinical diagnosis of thromboembolism is low, the true incidence is not well-known. A recent study has shown that the risk of DVT in the calf is approximately 30% (shown by ultrasonography screening of all patients in that study), regardless of surgical or non-surgical treatment¹³.

Technical advances and clinical experience have increased the advantage of colour duplex sonography, which is a non-invasive, less expensive and more convenient method for the patient. However, the accuracy of the method has to be studied further before it can be used as the 'gold standard' for diagnosing DVT. Most probably, thrombosis prevention should be employed in all patients who have sustained a total Achilles tendon rupture, regardless of treatment protocol.

PATIENT-REPORTED OUTCOME

It is important to use reliable, validated outcome measurements when evaluating treatment. Patient-reported outcomes have been more frequently used during the last decade to obtain the patients' own opinions about their results. When evaluating outcome, different functional tests together with the patient's opinion and complication registration are necessary to obtain an overall picture of the treatment results.

Evaluations of the treatment of an Achilles tendon rupture vary considerably among different studies. Clinical examination often includes calf muscle circumference, ankle range of motion and tendon width measurements. It has, however, never been shown that any of these factors are of importance in terms of function or patient satisfaction.

Accordingly, there is an obvious need for an outcome measurement, based on patient outcome and function and tested for reliability and validity. Such a score should be useful to compare outcome studies in the future.

A validated patient-reported outcome measurement exists for the evaluation of treatment of Achilles tendinopathy: the Victorian Institute of Sports Assessment-Achilles questionnaire (VISA-A

ACHILLES TENDON RUPTURE

Incidence, injury mechanism, treatment and evaluation

- 1** *Achilles tendon rupture is common and recent studies have reported an increasing incidence.*
- 2** *This increase is thought to be related to a greater interest in recreational sports activities.*
- 3** *The risk of an Achilles tendon rupture is 10× higher in males than females.*
- 4** *Acute Achilles tendon ruptures are frequently sustained in activities that involve running.*
- 5** *Sports-related Achilles tendon ruptures are most common in sportspeople aged 30 to 49 years (mean 40 years), but there is a second peak in older athletes of 60 to 65 years of age.*
- 6** *The most common injury mechanism is a sudden, forced ankle dorsiflexion, often in racket sports.*
- 7** *The diagnosis of an acute total Achilles tendon rupture is always clinical in the first place and additional examinations e.g. US and MRI are only needed occasionally. Additional examinations should not replace a thorough clinical examination.*
- 8** *Partial rupture is very uncommon and the diagnosis is probably incorrect in most cases; the tendon is almost always completely torn.*
- 9** *Surgical treatment is superior to non-surgical treatment in terms of lower risk of re-rupture and shorter sick-leave.*
- 10** *Surgical treatment is inferior to non-surgical treatment in terms of complication risks, especially scar adhesion, superficial infection, disturbed skin sensibility. However, there are no differences in terms of symptomatic DVT and extreme Achilles tendon lengthening (limited data on minor/moderate tendon lengthening, though).*
- 11** *There is no difference between surgical treatment and non-surgical treatments in terms of return to sports, provided no major complication (i.e. re-rupture) occurs.*
- 12** *The assessment systems should be more consistent. The Achilles Tendon Rupture Score has been well-tested for reliability and validity and can be the standard assessment system of all outcome studies in the future.*
- 13** *Most patients have not had any symptoms in the Achilles tendon before the rupture (e.g. tenderness, stiffness, pain). Typically, patients without previous symptoms report hearing a sudden audible "snap" in the calf. The patient often feels they have been hit from behind.*
- 14** *There are several areas that need further research such as surgical vs non-surgical treatment in a large-scale study (cohort size 500 patients or more in each group), the effect of tendon lengthening and standardisation of functional outcome testing and functional scores.*

POTENTIAL FUTURE RESEARCH

- *Larger comparative studies (RCT), probably multi-centre, regarding surgical vs non-surgical treatment. Should the primary outcome variable be re-rupture (or any other major complication) or functional outcome?*
- *Return to previous activity level. Why is the proportion of patients who are able to return to previous activity level low?*
- *Health economy. Which type of treatment is most favourable when it comes to overall cost?*
- *The effect of tendon lengthening, especially after non-surgical treatment. Better and more accurate methods are needed to measure the tendon lengthening. Does increased length of the Achilles tendon after treatment relate to inferior outcome?*
- *The impact of improved early-phase treatment, especially more active rehabilitation during the first 8 to 12 weeks, in terms of early range of motion and full weight-bearing.*
- *Similar or same functional outcome assessments should be standardised for all treatment studies, in order to facilitate comparison of studies and meta-analysis.*



questionnaire). A validated patient-reported outcome measurement is also available for foot and ankle injuries: the foot and ankle outcome score (FAOS). Since patients with an Achilles tendon rupture have different functional complaints and symptoms than patients with Achilles tendinopathy or ankle injuries, the use of the VISA-A and FAOS as an outcome measurement for this patient group can be questioned. To our knowledge, no validated scores for evaluating treatment in patients with an acute Achilles tendon rupture have been presented in the past. Accordingly, the Achilles Tendon total Rupture Score was constructed and has been tested for reliability and validity. It is also sensitive to changes over time. This functional outcome score is well-suited to evaluate the results after surgical or non-surgical treatment^{11,15}.

RECOVERY OF FUNCTION AND FUTURE PERSPECTIVES

The strength deficit of the calf musculature on the injured side 1 year after an Achilles tendon rupture is reported to be approximately 10 to 30% compared with the uninjured side, with large inter-individual variations, and it appears that this deficit becomes permanent^{14,15}. More than half of the patients are unable to perform a

one-legged heel raise after 3 months¹⁴. Moreover, early recovery of plantarflexion torque has not only been shown to indicate the normalisation of the calf musculature function, it also can be due to compensation by the flexor hallucis longus muscle. It is still not known whether tendon lengthening, especially after non-surgical treatment, is of importance when it comes to strength deficit in the long run. This needs to be examined further, with more accurate research methods than previously existed, for instance ultrasonography.

To evaluate muscle endurance, the most commonly used test is counting the number of consecutive heel rises the subject is able to perform until fatigue sets in on one leg and to compare this with the other leg. This test may need better standardisation in future.

The height of the heel rise may be important, since there is a disproportionate weakness in end-range plantarflexion. One explanation for this is tendon lengthening that may occur during the healing of the tendon. The theory that tendon lengthening is important in terms of functional recovery needs further studies. It is well known that extreme tendon lengthening has negative consequences, but the impact of minor/moderate tendon lengthening is not currently known¹⁵.

Studies have demonstrated that there is a separation of tendon ends after Achilles tendon repair. Interestingly, one study has shown that early motion resulted in a smaller degree of tendon separation than did immobilisation following Achilles tendon ruptures treated with surgery. The smaller degree of tendon separation also correlated with better clinical outcomes. This study is in accordance with the hypothesis that tendon lengthening may be of greater importance than previously realised.

The importance of changes in plantar flexion muscle forces and deficits in heel-rise heights have functional implications when it comes to the patients' ability to walk, run and jump. For the patients, the important outcomes of an Achilles tendon rupture are recovery of full function and the ability to return to previous activities, including sports without an increased risk of re-rupture and of developing other overuse injuries.

Interestingly, recent studies have shown that the number of patients that return to the previous activity level is rather low, approximately 50% in some studies. There are several reasons for this, one of them could be kinesiophobia i.e. fear of moving and fear of re-rupture.



Image: More than half of patients are unable to perform a one-legged heel raise after 3 months.

“ **most patients treated for Achilles tendon ruptures still have functional deficits 1 or 2 years after the injury, regardless of whether the treatment is surgical or non-surgical** ”

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