QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

Cite as: WRZESINSKA, Amadea, KOROWACKI, Mateusz, RUSIN, Iga, KAZIMIERCZAK, Karol, MĄCZKA, Krystian, KRUCZEK, Filip, DYCZKO, Jakub, ŚWIRAD, Bartosz, PRZYBYLSKI, Michal and GROBECKI, Daniel. Managing Achilles Tendinopathy: Current Evidence and Modern Strategies. Quality in Sport. 2026;61:73012. https://doi.org/10.12775/QS.2026.61.73012

ARTICLE TIMELINE
Received: 03.06.2026. Revised: 03.07.2026. Accepted: 04.07.2026. Published: 08.07.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

Managing Achilles Tendinopathy: Current Evidence and Modern Strategies

Amadea Wrzesińska, ORCID: https://orcid.org/0009-0001-5394-3446
E-mail: amadeawrzesinska@gmail.com
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Mateusz Korowacki, ORCID https://orcid.org/0009-0003-8100-3026
E-mail: matkorowacki@gmail.com
University Clinical Hospital in Wroclaw, Borowska 213, 50-556 Wrocław, Poland

Iga Rusin, ORCID https://orcid.org/0009-0002-4736-6571
E-mail: iga.rusin@wp.pl
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Karol Kazimierczak, ORCID: https://orcid.org/0009-0007-3748-5477
E-mail: karolkkazimierczak@gmail.com
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Krystian Mączka, ORCID https://orcid.org/0000-0002-9747-7926
E-mail: krystian_maczka@wp.pl
University Clinical Hospital in Wroclaw, Borowska 213, 50-556 Wrocław, Poland

Filip Kruczek, ORCID: https://orcid.org/0009-0002-3082-1435
E-mail: filipmkruczek@gmail.com
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Jakub Dyczko, ORCID https://orcid.org/0009-0006-6401-3945
E-mail: jakdyczko@gmail.com
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Bartosz Świrad, ORCID https://orcid.org/0009-0008-8158-7697
E-mail: barteks5698@gmail.com
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Michał Przybylski ORCID: https://orcid.org/0009-0007-8717-7392
E-mail: mrpmisiek@onet.pl
4th Military Clinical Hospital with Polyclinic SP ZOZ in Wroclaw, Rudolfa Weigla 5, 50-985 Wrocław

Daniel Grobecki, ORCID https://orcid.org/0009-0005-1724-7784
E-mail: danielgrobecki00@gmail.com
University Clinical Hospital in Wroclaw, Borowska 213, 50-556 Wrocław, Poland

Corresponding Author
Amadea Wrzesińska: amadeawrzesinska@gmail.com

Abstract

Introduction: Achilles tendon tendinopathy is a common degenerative disorder causing pain and functional limitation. Despite numerous treatment options, optimal management remains a clinical challenge.

Aim: To summarize current evidence on the pathophysiology, diagnosis, conservative treatment, modern adjunctive therapies, and surgical management of Achilles tendon tendinopathy

Materials and methods: This narrative review is based on scientific literature, including guidelines, systematic reviews, and clinical studies. Particular attention was paid to diagnostic methods, progressive rehabilitation, extracorporeal shockwave therapy (ESWT), injections (PRP, hyaluronic acid, high-volume), fenestration, stem cells, and surgery.

Results: Diagnosis is primarily clinical, with ultrasound and MRI reserved for unclear or resistant cases. Conservative treatment is the first-line approach, focusing on load management and structured rehabilitation (e.g., the Alfredson protocol). Modern adjunctive therapies and injections may provide benefits, though evidence quality varies. Surgical treatment is reserved for persistent cases failing conservative therapy.

Conclusions: Effective management requires an individualized, multidisciplinary approach centered on patient education, load modification, and evidence-based rehabilitation. Biological and minimally invasive therapies serve as adjuncts, but further high-quality studies are needed

Keywords: Achilles tendinopathy; Achilles tendon; eccentric exercise; extracorporeal shockwave therapy; platelet-rich plasma; rehabilitation; surgical treatment.

Introduction

Achilles tendon tendinopathy is one of the most common causes of posterior ankle pain and functional limitation, affecting both physically active individuals and the general population [2,5,8]. It is particularly frequent among runners and athletes involved in jumping sports, but it may also occur in sedentary individuals, especially after a sudden increase in physical activity or tendon loading [3,5,8]. The condition can significantly reduce quality of life by limiting sport participation, occupational activity, and everyday functioning [5].

Current evidence indicates that Achilles tendon tendinopathy is primarily a degenerative rather than inflammatory disorder [1,8]. The pathological process involves disorganization of collagen fibers, altered extracellular matrix remodeling, increased tenocyte activity, neovascularization, and impaired tendon load tolerance [1,2,8]. Repetitive mechanical overload and insufficient tendon adaptation are considered central mechanisms leading to chronic pain and progressive functional impairment [1,8].

Several intrinsic and extrinsic risk factors may contribute to the development of Achilles tendon tendinopathy. These include sudden changes in training volume or intensity, training errors, reduced calf muscle flexibility, inappropriate footwear, obesity, metabolic disorders, and systemic inflammatory diseases [5,8]. Age-related tendon changes and exposure to certain medications, particularly fluoroquinolones and systemic glucocorticosteroids, may further increase susceptibility to tendon injury [5,8].

Diagnosis is based primarily on clinical assessment, including medical history and physical examination, while imaging methods such as ultrasound and magnetic resonance imaging are useful in unclear, chronic, or treatment-resistant cases [5,20,22,23]. Conservative treatment remains the first-line approach, with activity modification and progressive loading-based rehabilitation forming the foundation of management [5,8]. Eccentric exercise programs, including the Alfredson protocol, are among the most established conservative interventions for midportion Achilles tendinopathy [3-5].

Despite the availability of multiple therapeutic options, the optimal management of Achilles tendon tendinopathy remains a subject of ongoing debate [5,8]. Modern adjunctive methods, including extracorporeal shockwave therapy, platelet-rich plasma injections, hyaluronic acid injections, tendon fenestration, high-volume injections, and stem cell-based therapies, have gained increasing interest, particularly in patients who fail to respond to standard conservative treatment [9-19]. However, the quality and consistency of evidence supporting these approaches vary, and their role in routine clinical practice remains incompletely defined [9-19].

The aim of this review is to summarize the current state of knowledge regarding the pathophysiology, diagnosis, conservative management, modern therapeutic methods, and surgical treatment of Achilles tendon tendinopathy, with particular emphasis on evidence-based clinical decision-making.

Pathophysiology of Achilles tendon tendinopathy

Achilles tendon tendinopathy is a complex, multifactorial disorder in which degenerative changes predominate over classical inflammation [1,2,8]. Repetitive mechanical overload may disturb the balance between collagen synthesis and degradation, leading to progressive structural disorganization of the tendon matrix and impaired load tolerance [1,8]. As a result, the tendon becomes more susceptible to micro-injury, chronic pain, and functional limitation [1,2,8].

The Achilles tendon is composed mainly of type I collagen fibers, which provide tensile strength and resistance to mechanical loading [1,8]. In tendinopathy, the proportion of type I collagen decreases, while type III collagen and extracellular matrix components, including proteoglycans and glycosaminoglycans, increase [1,8]. These changes are associated with collagen fiber disorganization, tendon thickening, swelling, and reduced mechanical strength [1,8].

Neovascularization is another characteristic feature of chronic Achilles tendinopathy [2,8]. The formation of new blood vessels within the diseased tendon is often accompanied by ingrowth of sensory nerve fibers, which may contribute to chronic pain generation [2,8]. Doppler ultrasound may demonstrate increased vascularity in symptomatic tendons, although the relationship between neovascularization and pain is not always linear [7,8].

Micro-injuries caused by repetitive loading play an important role in the development and progression of Achilles tendon tendinopathy [1,2]. The midportion of the Achilles tendon, located approximately 2–6 cm proximal to the calcaneal insertion, is particularly vulnerable to degeneration because of relatively poorer vascular supply and high mechanical stress [2,5]. Reduced local perfusion may impair tissue repair and promote persistence of degenerative changes [2,8].

At the cellular level, tendinopathy is associated with increased tenocyte activity, altered cell morphology, and disturbed regulation of extracellular matrix turnover [1,8]. Increased activity of matrix metalloproteinases may contribute to collagen degradation and weakening of the tendon structure [8]. These processes may gradually reduce tendon stiffness and strength, increasing susceptibility to partial or complete rupture [1,8].

Systemic and patient-related factors also influence the development of Achilles tendon tendinopathy [5,8]. Obesity, diabetes, hypercholesterolemia, inflammatory rheumatic diseases, and increasing age may impair tendon metabolism, alter collagen structure, and reduce

regenerative capacity [5,8]. Medication exposure, particularly fluoroquinolones and systemic glucocorticosteroids, may additionally increase the risk of tendon injury and rupture [5,8].
In summary, Achilles tendon tendinopathy results from an interaction between mechanical overload, failed tendon healing, extracellular matrix disorganization, neovascularization, and systemic risk factors [1,2,8]. Understanding these mechanisms is essential for selecting appropriate treatment strategies, particularly interventions based on load management, progressive rehabilitation, and biological modulation of tendon repair [1,5,8].

Diagnosis of Achilles tendon tendinopathy

Diagnosis of Achilles tendon tendinopathy is based primarily on a carefully collected medical history and physical examination, which in most cases allow for an initial clinical diagnosis [5,20]. Imaging studies are complementary and are particularly useful in unclear cases, chronic symptoms, suspected partial tendon rupture, or lack of response to conservative treatment [5,22,23].

Medical history

Patients with Achilles tendon tendinopathy most commonly report posterior ankle pain that increases during tendon-loading activities, such as running, jumping, or walking upstairs [5,20]. Morning stiffness and pain after a period of rest, with partial symptom relief during initial movement, are also characteristic clinical features [5,20]. As the disease progresses, symptoms may occur during daily activities and, in advanced cases, even at rest [5,20].

The medical history should include potential risk factors, such as a sudden increase in training load, changes in footwear, hard running surfaces, obesity, metabolic disease, and systemic inflammatory or rheumatic disorders [5,8]. Medication history is also important, particularly exposure to fluoroquinolones or systemic glucocorticosteroids, which may increase the risk of tendon pathology [5,8].

Physical examination

On physical examination, localized tenderness along the Achilles tendon is typically present, most commonly in the midportion, approximately 2–6 cm proximal to the calcaneal insertion [2,5,20]. Tendon thickening and reduced flexibility of the gastrocnemius–soleus complex may

also be observed [5,20]. Palpable nodules or irregularities may suggest chronic structural tendon changes [5,20].

Functional assessment should include evaluation of ankle range of motion and tendon-loading tests, such as the single-leg heel raise, which may reproduce symptoms and help assess functional limitation [5,20,21]. Increased calf muscle tension and limited gastrocnemius–soleus flexibility may contribute to symptoms and should be assessed during examination [5]. A key diagnostic step is differentiating midportion Achilles tendinopathy from insertional tendinopathy, as these conditions may differ in clinical presentation, imaging findings, and therapeutic approach [5,20,23].

Imaging

Imaging may help confirm the diagnosis, assess the extent of tendon abnormalities, and identify differential diagnoses or coexisting pathology [5,22,23]. Ultrasonography is commonly used to assess tendon thickness, structural disorganization, hypoechoic areas, calcifications, and neovascularization using Doppler imaging [7,22,23]. Ultrasound is widely available, non-invasive, dynamic, and relatively inexpensive, which makes it a practical first-line imaging modality in many clinical settings [5,7,23].

Magnetic resonance imaging provides detailed assessment of the tendon and surrounding soft tissues and may be particularly useful when the diagnosis is uncertain or when partial rupture, insertional pathology, or other coexisting disorders are suspected [5,22,23]. MRI is also useful in patients with persistent symptoms despite conservative treatment and in preoperative planning [5,22,23]. Plain radiography has limited value in diagnosing tendinopathy itself but may help identify calcifications, enthesophytes, Haglund deformity, or other bony abnormalities associated with insertional symptoms [5,23].

Differential diagnosis

Differential diagnosis should include other causes of posterior ankle pain, such as retrocalcaneal bursitis, Haglund syndrome, partial Achilles tendon tear, plantaris-related pain, posterior ankle impingement, plantar fasciitis, and ankle joint pathology [5,20,23]. Accurate differentiation is essential because treatment strategies differ between midportion tendinopathy, insertional tendinopathy, partial rupture, and other posterior ankle disorders [5].

Patient-reported outcome measures

Patient-reported outcome measures may be useful for assessing baseline symptom severity and monitoring treatment response. The Victorian Institute of Sport Assessment-Achilles questionnaire (VISA-A) is one of the most commonly used tools for evaluating pain, function, and activity limitation in patients with Achilles tendinopathy [24].

In summary, the diagnosis of Achilles tendon tendinopathy is primarily clinical and should be supported by imaging when symptoms are atypical, persistent, or suggest another pathology [5,20,22,23]. Early and accurate diagnosis allows appropriate conservative management and may reduce the risk of chronic symptoms and delayed recovery [5].

Conservative treatment of Achilles tendon tendinopathy

Conservative treatment is the first-line approach in the management of Achilles tendon tendinopathy and is effective in many patients, particularly when based on structured rehabilitation and appropriate load management [5,8]. The main therapeutic goals are reduction of pain, restoration of lower-limb function, improvement of tendon load tolerance, and prevention of symptom recurrence [5].

Modification of physical activity

The initial stage of treatment involves reducing or modifying activities that excessively load the Achilles tendon [5]. However, complete immobilization is generally not recommended, as progressive mechanical loading is important for tendon adaptation and recovery [5,8]. Temporary replacement of high-impact activities, such as running and jumping, with lower-load exercises, including cycling or swimming, may help maintain physical activity while reducing tendon overload [5].

Correction of training errors, gradual return to sport, footwear modification, and avoidance of hard training surfaces are important elements of conservative management [5]. In selected patients, heel lifts, insoles, or orthotic devices may be used as adjunctive measures to reduce mechanical strain on the Achilles tendon [5].

Rehabilitation and eccentric exercises

Rehabilitation is the cornerstone of conservative treatment and should be based on progressive tendon loading [5,8]. Eccentric calf-muscle exercises are among the best-supported conservative interventions for midportion Achilles tendinopathy [3-5]. The

proposed mechanisms include improved tendon load tolerance, remodeling of collagen structure, pain modulation, and possible effects on neovascularization [1,3,8].

The Alfredson heel-drop protocol remains one of the most frequently cited exercise programs for chronic midportion Achilles tendinopathy [3,4]. It typically consists of eccentric heel-drop exercises performed over a 12-week period, with progressive loading according to patient tolerance [3,4]. Long-term follow-up data suggest that eccentric loading may reduce pain and improve function in many patients, although treatment response may vary depending on symptom duration, adherence, tendon location, and individual loading capacity [4,5].

In addition to eccentric exercises, rehabilitation may include calf muscle stretching, progressive strengthening, neuromuscular training, and selected manual therapy techniques [5,6]. Tendon neuroplastic training, which combines strength-based loading with external pacing or motor-control strategies, has also been proposed as a method to improve tendon-related pain and motor function [6]. Rehabilitation should be individualized and gradually progressed according to pain response, functional capacity, and treatment goals [5].

Pharmacotherapy

Pharmacotherapy has mainly a symptomatic role in Achilles tendon tendinopathy [5,8]. Non-steroidal anti-inflammatory drugs may be used for short-term pain relief, but their role in chronic tendinopathy is limited because the underlying pathology is predominantly degenerative rather than inflammatory [1,8]. Therefore, pharmacological treatment should not replace load-based rehabilitation [5,8].

Corticosteroid injections remain controversial. Although they may provide short-term pain reduction, their use around the Achilles tendon is limited by concerns regarding tendon weakening and increased risk of rupture [5,8]. For this reason, corticosteroid injections should be used cautiously and are generally not recommended as routine treatment for Achilles tendon tendinopathy [5].

Orthoses and orthopedic supplies

Orthotic devices may be used as adjuncts in selected patients, particularly during periods of increased pain or during gradual return to activity [5]. Heel lifts can reduce Achilles tendon strain by decreasing ankle dorsiflexion demand and shortening the functional length of the gastrocnemius–soleus complex [5]. Stabilizing orthoses may provide temporary symptom relief, but they should not replace progressive loading-based rehabilitation [5].

Physical therapy modalities

Physical therapy modalities such as therapeutic ultrasound, laser therapy, and cryotherapy may be used as adjunctive treatments, although the evidence supporting their effectiveness is variable [5]. These methods may help reduce pain in selected patients, but they should be regarded as supplementary rather than primary treatment strategies [5,8].

Extracorporeal shockwave therapy may be considered in chronic Achilles tendinopathy, particularly when symptoms persist despite exercise-based rehabilitation [5,11]. Current evidence suggests that ESWT may improve pain and function in some patients, although the quality of evidence remains variable and it should generally be used as an adjunct rather than a replacement for structured rehabilitation [5,11].

In summary, conservative treatment of Achilles tendon tendinopathy should be based primarily on activity modification and progressive loading exercises, with eccentric training remaining one of the most established rehabilitation methods [3-5,8]. Pharmacotherapy, orthoses, and physical therapy modalities may be useful adjuncts, but they should not replace individualized rehabilitation and careful load management [5,8].

Modern methods of treating Achilles tendon tendinopathy

In recent years, there has been a dynamic development of adjunctive and regenerative treatment methods for Achilles tendon tendinopathy, particularly in patients who do not respond adequately to structured loading-based rehabilitation [5,8]. These techniques are mainly considered in patients for whom classical conservative treatment has not brought satisfactory results [5].

Platelet-rich plasma

One of the most commonly studied biological methods in Achilles tendon tendinopathy is platelet-rich plasma injection [9,10]. PRP is obtained from the patient’s own blood and contains concentrated platelets and growth factors that may modulate tissue repair processes [9,10]. Proposed mechanisms include stimulation of tenocyte and fibroblast activity, modulation of collagen synthesis, and local release of growth factors; however, translation of these biological effects into clinical benefit remains uncertain [9,10]. Although some studies report improvement in pain and function after PRP injection, systematic reviews and meta-analyses show inconsistent results and do not clearly confirm superiority over placebo or exercise-based rehabilitation [9,10].

Shockwave therapy

Extracorporeal shock wave therapy is another adjunctive method used in chronic Achilles tendon tendinopathy, particularly when symptoms persist despite exercise-based rehabilitation [5,11]. Proposed mechanisms include pain modulation, stimulation of local tissue repair responses, and effects on microcirculation, although the exact mechanisms remain incompletely understood [8,11]. Current evidence suggests that ESWT may reduce pain and improve functional outcomes in Achilles tendinopathy, although effects on tendon structure and neovascularization are less consistently demonstrated [11]. ESWT appears most clinically relevant as an adjunct to structured rehabilitation, including eccentric or progressive loading exercises, rather than as a stand-alone replacement for exercise therapy [5,11].

Stem cells

There is growing interest in stem cell-based therapies for chronic tendon disorders, including Achilles tendinopathy [17,18]. The rationale for stem cell therapy is based on the potential ability of mesenchymal stromal cells to modulate inflammation, influence extracellular matrix remodeling, and support tendon repair processes [17]. Preliminary clinical evidence suggests that autologous bone marrow-derived mesenchymal stromal cells may be safe and may improve clinical outcomes in selected patients with Achilles tendinopathy, but evidence remains limited [18]. Therefore, stem cell therapy should currently be regarded as investigational rather than routine clinical treatment, and further controlled trials with longer follow-up are needed [17,18].

Dry needling and tendon fenestration

Dry needling and tendon needling have been investigated as minimally invasive treatment options for chronic tendinopathy [12,14]. The procedure involves repeated needle fenestration of the pathological tendon tissue, aiming to induce a controlled local healing response [13,14]. Tendon needling may be performed alone or combined with autologous blood products or other injectable therapies, although the added benefit of combination treatment remains uncertain [14]. Available evidence suggests that tendon needling may improve patient-reported outcomes in tendinopathy, but the quality and heterogeneity of studies limit firm conclusions [12,14].

Hyaluronic acid injections

Peritendinous hyaluronic acid injections have also been evaluated as a treatment option for painful Achilles tendinopathy [15,16]. The proposed benefits include reduction of peritendinous friction, modulation of pain, and improvement of tendon gliding, although the precise clinical mechanism remains uncertain [15,16]. In a randomized clinical study, peritendinous hyaluronan injections showed favorable efficacy and safety compared with ESWT in painful midportion Achilles tendinopathy, while prospective data also suggest potential benefit in painful tendinopathies [15,16].

High-volume injections

High-volume injections have recently been investigated as a minimally invasive option for Achilles tendinopathy, particularly in chronic cases associated with neovascularization and persistent pain [19]. The proposed mechanism includes mechanical disruption of neovessels and accompanying nerve ingrowth, as well as reduction of peritendinous adhesions [19]. Current systematic review evidence suggests short-term pain reduction and acceptable safety, although robust randomized trials with longer follow-up are still needed [19].

Other biological methods

Other injectable and biological approaches, including autologous blood-derived products and prolotherapy, have been investigated, but the quality of evidence is variable and these methods should generally be considered adjunctive or investigational [8-10].

In summary, modern methods of treating Achilles tendon tendinopathy may be useful as adjuncts in selected patients, particularly when structured rehabilitation alone is insufficient. At present, the strongest clinical relevance appears to belong to ESWT and selected injectable therapies, while PRP, stem cell therapy, tendon fenestration, hyaluronic acid, and high-volume injections require careful patient selection and further high-quality comparative studies [5,9-19].

Surgical treatment of Achilles tendon tendinopathy

Surgical treatment of Achilles tendon tendinopathy is reserved for patients who do not achieve satisfactory clinical improvement after an adequate period of conservative management [5,8]. In most cases, surgery is considered only after at least 3–6 months of

structured non-operative treatment, including activity modification, progressive loading exercises, and adjunctive therapies when appropriate [5]. The decision to proceed with surgery should be individualized and should take into account symptom duration, functional limitation, imaging findings, patient age, activity level, and expectations [5,8].

Indications for surgical treatment

The main indication for surgical treatment is persistent pain and functional limitation despite properly conducted conservative therapy [5,8]. Surgery may also be considered in patients with advanced degenerative changes, partial tendon tears, marked tendon thickening, insertional tendinopathy with calcifications or bony impingement, or symptoms that significantly limit work, sport, or daily activities [2,5,8].

It is important to distinguish between midportion and insertional Achilles tendinopathy, as the surgical approach differs depending on the location and type of pathology [5,23]. In midportion tendinopathy, treatment is usually directed at removal of degenerative intratendinous tissue and decompression of the tendon [2,5]. In insertional tendinopathy, surgery may additionally involve removal of calcifications, resection of posterosuperior calcaneal prominence, treatment of retrocalcaneal bursitis, and reinsertion of the tendon if necessary [5,23].

Surgical techniques

The most common surgical procedures include debridement of degenerative tendon tissue, decompression of peritendinous structures, and removal of adhesions or pathological tissue [2,5,8]. These procedures aim to reduce pain, improve tendon gliding, remove mechanically irritating tissue, and stimulate local healing [5,8].

Open surgery allows direct visualization and removal of diseased tendon tissue, but it is associated with a higher risk of wound-related complications compared with less invasive approaches [2,5]. Minimally invasive and endoscopic techniques have gained increasing interest because they may reduce soft-tissue trauma, shorten recovery time, and lower the risk of wound complications [5,23]. However, the choice of technique should depend on the location and extent of tendon pathology, surgeon experience, and patient-specific factors [5].

Minimally invasive procedures

Minimally invasive procedures include percutaneous tendon scraping, endoscopic decompression, ultrasound-guided interventions, and limited debridement of pathological tissue [5,13,23]. These techniques are particularly attractive in chronic tendinopathy associated with neovascularization and peritendinous pain generators [8,13]. Ultrasound-guided procedures may help precisely target pathological areas while limiting damage to surrounding tissues [13,23].

Although minimally invasive techniques may offer faster recovery and fewer wound complications, evidence comparing them directly with open surgery remains limited [5,8]. Therefore, they should be considered in selected patients and performed by clinicians experienced in the management of Achilles tendon pathology [5,23].

Tendon reconstruction

In advanced cases with extensive degeneration or significant tendon defects, tendon reconstruction may be required [2,5]. Reconstruction is most commonly performed using tendon transfer, such as flexor hallucis longus transfer, particularly when the remaining Achilles tendon tissue is insufficient for durable repair [5,8]. The goal of reconstruction is to restore continuity, improve plantarflexion strength, reduce pain, and allow gradual return to functional activity [5]. Postoperative rehabilitation is essential after reconstructive procedures and should involve protected weight-bearing followed by progressive loading and strengthening [5]. Return to sport or high-demand activity may require prolonged rehabilitation and should be guided by pain, strength, range of motion, and functional recovery [5].

Complications

Surgical treatment of Achilles tendon tendinopathy carries a risk of complications, including wound infection, delayed wound healing, skin necrosis, sural nerve irritation or injury, persistent pain, stiffness, and recurrence of symptoms [2,5,8]. Wound-related complications are particularly relevant because of the relatively limited soft-tissue envelope and vascularity around the Achilles tendon [2,8].

Minimally invasive techniques may reduce the risk of wound complications, but they do not eliminate the possibility of nerve irritation, incomplete debridement, persistent symptoms, or

recurrence [5,13,23]. Careful patient selection, appropriate surgical technique, and structured postoperative rehabilitation are therefore essential for optimizing outcomes [5].

Outcomes of surgical treatment

Most studies report clinical improvement after surgery in patients with chronic Achilles tendinopathy resistant to conservative treatment [2,5,8]. However, postoperative recovery can be prolonged, and return to full physical activity may require several months of rehabilitation [5]. Outcomes depend on several factors, including the type of tendinopathy, severity of degenerative changes, surgical technique, patient comorbidities, adherence to rehabilitation, and preoperative functional status [5,8].

In conclusion, surgical treatment is an effective option for selected patients with persistent Achilles tendon tendinopathy after failed conservative therapy [5,8]. Nevertheless, it should be considered a second-line strategy after structured rehabilitation, and the choice of surgical technique should be individualized according to tendon location, imaging findings, and patient-specific functional goals [5,23].

Conclusions

Achilles tendon tendinopathy is a common and clinically significant disorder affecting both physically active individuals and sedentary patients. Its pathophysiology is multifactorial and primarily degenerative rather than inflammatory, involving collagen disorganization, impaired tendon remodeling, neovascularization, and altered load tolerance [1,2,8].

Diagnosis is based mainly on medical history and physical examination, while imaging methods such as ultrasound and magnetic resonance imaging are useful in unclear cases, persistent symptoms, suspected partial rupture, or preoperative planning [5,20,22,23]. Differentiating midportion from insertional Achilles tendinopathy is essential, as these entities may require different therapeutic strategies [5,23].

Conservative treatment remains the first-line approach and should focus on activity modification, progressive tendon loading, and structured rehabilitation [5,8]. Eccentric exercises, including the Alfredson heel-drop protocol, remain one of the most established treatment methods, although rehabilitation should be individualized according to symptoms, function, and patient goals [3-5].

Modern therapeutic methods may serve as adjuncts in selected patients, particularly when symptoms persist despite properly conducted conservative treatment [5,8]. Current evidence

suggests potential benefit from ESWT and selected injectable therapies, but the effectiveness of PRP, hyaluronic acid, tendon fenestration, high-volume injections, and stem cell-based therapies remains variable and requires further high-quality comparative studies [9-19].

Surgical treatment should be reserved for patients with persistent pain and functional limitation despite adequate conservative therapy [5,8]. The choice of surgical technique should be individualized according to the location and severity of tendon pathology, imaging findings, patient activity level, and treatment expectations [5,23].

Overall, effective management of Achilles tendon tendinopathy requires a comprehensive and multidisciplinary approach combining orthopedics, rehabilitation, sports medicine, and patient education. Early diagnosis, appropriate load management, and evidence-based conservative treatment remain central to improving outcomes and reducing the risk of chronic symptoms or delayed recovery [5,8,20].

Disclosure

Author's contribution:

Conceptualization: Amadea Wrzesińska, Iga Rusin, Mateusz Korowacki

Methodology: Krystian Mączka, Karol Kazimierczak

Software: Iga Rusin, Karol Kazimierczak

Check: Jakub Dyczko, Daniel Grobecki, Bartosz Świrad

Formal analysis: Mateusz Korowacki, Michał Przybylski

Investigation: Karol Kazimierczak, Iga Rusin

Resources: Amadea Wrzesińska, Filip Kruczek, Michał Przybylski

Data curation: Iga Rusin, Mateusz Korowacki, Filip Kruczek

Writing-rough preparation: Daniel Grobecki, Michał Przybylski, Bartosz Świrad

Writing review and editing:, Krystian Mączka, Filip Kruczek, Jakub Dyczko

Visualisation: Karol Kazimierczak, Jakub Dyczko

Supervision: Mateusz Korowacki, Amadea Wrzesińska

Project administration:Iga Rusin

Receiving funding**:** Not applicable - no specific funding

All authors have read and agreed with the published version of the manuscript.

Funding statement: The Study Did Not Receive Special Funding.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Applicable

Data Availability Statement: Not Applicable.

Conflict of Interest: The authors declare no conflicts of interest.

In preparing this work, the authors used Chat GPT for the purpose of improving language and readability. After using this tool/service, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

References

1. Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med. 2009;43(6):409–416.
2. Maffulli N, Kader D. Tendinopathy of tendo Achillis. J Bone Joint Surg Br. 2002;84(1):1–8.
3. Alfredson H, Lorentzon R. Chronic Achilles tendinosis: recommendations for treatment and prevention. Sports Med. 2000;29(2):135–146.
4. van der Plas A, de Jonge S, de Vos RJ, van der Heide HJ, Verhaar JAN, Weir A. A 5-year follow-up study of Alfredson's heel-drop exercise programme in chronic Achilles tendinopathy. Br J Sports Med. 2012;46(3):214–218.
5. Martin RL, Chimenti R, Cuddeford T, et al. Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy Revision 2018. J Orthop Sports Phys Ther. 2018;48(5):A1–A38.

6. Rio E, Kidgell D, Moseley GL, Gaida J, Docking S, Purdam C, Cook J. Tendon neuroplastic training: changing the way we think about tendon rehabilitation. Br J Sports Med. 2016;50(4):209–215.
7. Bianchi S, Martinoli C. Ultrasound of the musculoskeletal system. Berlin: Springer; 2007.
8. Rees JD, Maffulli N, Cook J. Tendinopathy: pathophysiology and management. Lancet. 2014;383(9924):1058–1068.
9. Gatz M, Driessen A, Eschweiler J, Migliorini F, Tingart M, Rath B. Platelet-rich plasma in Achilles tendinopathy: a systematic review. Am J Sports Med. 2020;48(8):2067–2077.
10. Ling SKK, Lui TH, Yung PSH. *Effect of platelet-rich plasma injection on the treatment of Achilles tendinopathy: a systematic review and meta-analysis.* Orthop J Sports Med. 2024;12(11):23259671241296508.
11. Stania M, Słomka KJ, Juras G, Król T, Król P. The efficacy of extracorporeal shock wave therapy as a monotherapy for Achilles tendinopathy: a systematic review and meta-analysis. *J Foot Ankle Surg*. 2023;62(5):989–997.
12. Nuhmani S, Khan MH, Ahsan M, Abualait TS, Muaidi Q. *Dry needling in the management of tendinopathy: a systematic review of randomized control trials.* J Bodyw Mov Ther. 2023;33:128–135.
13. Chiavaras MM, Jacobson JA. *Ultrasound-guided tendon fenestration.* Semin Musculoskelet Radiol. 2013;17(1):85–90.
14. Krey D, Borchers J, McCamey K. *Tendon needling for treatment of tendinopathy: a systematic review.* Phys Sportsmed. 2015;43(1):80–86.
15. Lynen N, De Vroey T, Spiegel I, Van Ongeval F, Hendrickx NJ, Stassijns G. *Comparison of peritendinous hyaluronan injections versus extracorporeal shock wave therapy in the treatment of painful Achilles' tendinopathy: a randomized clinical efficacy and safety study.* Arch Phys Med Rehabil. 2017;98(1):64–71.
16. Fogli M, Giordan N, Mazzoni G. *Efficacy and safety of hyaluronic acid ultrasound-guided injections on painful tendinopathies: a prospective, open-label clinical study.* Muscles Ligaments Tendons J. 2017;7(2):388–395.
17. van den Boom NAC, Winters M, Haisma HJ, Moen MH. *Efficacy of stem cell therapy for tendon disorders: a systematic review.* Orthop J Sports Med. 2020.

18. Goldberg AJ, Masci L, O'Donnell P, et al. *Autologous bone marrow derived mesenchymal stem cells are safe for the treatment of Achilles tendinopathy.* Sci Rep. 2024;14(1):11421.
19. Hassan R, Poku D, Miah N, Maffulli N. *High-volume injections in Achilles tendinopathy: a systematic review.* Br Med Bull. 2024;152(1):35–47.
20. Matthews W, Ellis R, Furness J, Rathleff MS, Vicenzino B, Stasinopoulos D. The clinical diagnosis of Achilles tendinopathy: a scoping review. *PeerJ*. 2021;9:e12166.
21. Hutchison AM, Evans R, Bodger O, et al. What is the best clinical test for Achilles tendinopathy? *Foot Ankle Surg*. 2013;19(2):112–117.
22. Gatz M, Spang C, Alfredson H. Multimodal ultrasound versus MRI for the diagnosis and monitoring of Achilles tendinopathy: a prospective longitudinal study. *Orthop J Sports Med*. 2021;9(4):23259671211006826.
23. Pass B, Robinson P. The Achilles tendon: imaging diagnoses and image-guided interventions. *Semin Musculoskelet Radiol*. 2022;26(2):145–156.
24. Robinson JM, Cook JL, Purdam C, et al. The VISA-A questionnaire: a valid and reliable index of the clinical severity of Achilles tendinopathy. *Br J Sports Med*. 2001;35(5):335–341.