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Special Article

Achilles tendon rupture: discussion and updates

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Abstract

Achilles tendon rupture is a common injury, especially in athletes and active individuals, that presents significant challenges in treatment and recovery. This article reviews current approaches, controversies, and recent advances in managing this condition. The ongoing debate between surgical and conservative treatment highlights the need for a personalized therapeutic choice, considering the nature of the injury and the patient's profile. While surgery traditionally offers lower re-rupture rates, advances in minimally invasive techniques and accelerated rehabilitation have demonstrated similar efficacy with fewer complications. Innovations such as biological therapies, extracellular matrix grafts, and functional immobilization devices are changing the treatment scenery, although their effectiveness is still under evaluation. In addition, tissue engineering, cell therapies, and remote monitoring research open new possibilities for improving healing and rehabilitation. Prospects include an increasingly personalized and technological approach with the potential to optimize outcomes and reduce re-rupture rates.

Level of evidence V; Expert opinion.

Keywords: Achilles tendon; Therapy; Orthopedics; Injury.

Introduction

Achilles tendon rupture is a common orthopedic injury that predominantly affects active adults, particularly those involved in sports that require explosive movements, such as jumping and running. This tendon, the strongest in the human body, connects the gastrocnemius and soleus muscles to the calcaneus, playing a crucial role in locomotion. Despite its robustness, the Achilles tendon is vulnerable to injury, especially in individuals with risk factors such as advanced age, sudden increase in physical activity, and use of certain medications, such as corticosteroids and fluoroquinolones[1].

Achilles tendon rupture has increased in recent decades, reflecting population aging and increased participation in physical activity. The injury is characterized by a partial or complete rupture of tendon fibers, resulting in acute pain, edema, and sudden loss of plantar function. Diagnosis is usually clinical, supported by imaging tests such as ultrasound and magnetic resonance imaging (MRI) to confirm the extent of the injury[2].

Managing Achilles tendon rupture remains controversial, with debates surrounding conservative versus surgical approaches. Traditionally, surgical treatment was considered the gold standard to minimize the risk of re-rupture and restore full function. However, advances in rehabilitation and functional immobilization techniques have demonstrated comparable results with nonsurgical treatment in certain patients, challenging established practices[3].

The objective of this article is to discuss the latest updates in the diagnosis, treatment, and prognosis of Achilles tendon rupture.

Methods

This study is a narrative review, and the search was conducted in PubMed, Scopus, and Web of Science databases to identify relevant articles published between 2000 and 2023. Search terms such as "Achilles tendon rupture," "treatment," "diagnosis," "rehabilitation," "re-rupture," and "complications"

Study performed at the Hospital Municipal Salgado Filho, Rio de Janeiro, RJ, Brazil.

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were used. The research was limited to studies in English. Articles that presented data on the diagnosis, treatment, and rehabilitation results of patients with Achilles tendon rupture were included. Studies that focused on different injuries or did not provide detailed information on clinical outcomes were excluded. The selected articles were reviewed, and the analysis included the diagnostic methods used, the therapeutic interventions described, the rehabilitation protocols, and the reported outcomes, such as re-rupture rates, return to physical activity, and associated complications.

The extracted data were organized into thematic categories to synthesize the information in a coherent and accessible way. Data synthesis included the comparison of different treatment approaches, analysis of complication risk factors, and discussion of current guidelines for managing Achilles tendon rupture.

Results and discussion

Physiopathology

Achilles tendon rupture occurs due to structural failure in the collagen fibers that make up this tendon, the strongest in the human body. The Achilles tendon is mainly formed by type I collagen, which provides resistance and the ability to withstand large tensile loads. It connects the gastrocnemius and soleus muscles to the calcaneus bone, essential in transmitting the force required for plantar flexion, allowing movements such as walking, running, and jumping[1].

The physiopathology of Achilles tendon rupture is closely linked to biomechanical, degenerative, and vascular factors. In biomechanical factors, the Achilles tendon is subjected to repetitive forces and high loads, particularly during explosive movements such as running and jumping. These forces can lead to cumulative microtraumas, compromising the tendon's structural integrity. When the tendon is compromised, an abrupt movement or excessive load can rupture[2].

Tendon degeneration, known as tendinopathy, is a common predisposing factor for Achilles tendon rupture. With aging, the Achilles tendon can undergo degenerative changes, including disorganization of collagen fibers, increased extracellular matrix (ECM), and decreased vascularization. These changes compromise tendon resistance and increase susceptibility to ruptures, especially in individuals over 30 years of age, who are more likely to present these degenerative changes[3].

Vascular factors also play a significant role in the pathophysiology of Achilles tendon rupture. The tendon region, known as the "hypovascular zone" or "critical zone," located approximately 2 to 6 cm above the calcaneal insertion, has relatively poor vascularization, which limits the supply of nutrients and oxygen to the tendon fibers. This vascular deficit can contribute to degeneration and inadequate tendon healing, facilitating the development of rupture[4].

In addition, extrinsic and intrinsic factors can influence the risk of rupture. The use of corticosteroids and fluoroquinolones has been associated with an increased risk of tendon injury due to their negative impact on collagen synthesis and cellular function within the tendon. Obesity, diabetes, and chronic inflammatory diseases can also affect Achilles tendon health, increasing the likelihood of rupture[5].

Diagnostic

Early and accurate diagnosis of Achilles tendon rupture is essential for effectively managing the injury and optimizing functional outcomes. The rupture can be partial or complete, and the diagnostic approach must be thorough to differentiate between these conditions and other injuries that can mimic the symptoms[6].

The initial diagnosis is often based on clinical evaluation, which includes a detailed patient history and a focused physical examination. Patients with Achilles tendon rupture usually report the sensation of a sudden "pop" or sharp pain in the posterior region of the leg, followed by difficulty or inability to walk. Physical examination may reveal characteristic signs, such as edema, hematoma, and a palpable tendon defect, approximately 2 to 6 cm above the calcaneal insertion[7].

Two clinical tests are widely used to confirm the diagnosis:

Thompson's test: During this test, the patient is positioned in prone position with their feet hanging. Calf compression should normally cause plantar flexion of the foot. The absence of movement suggests a complete Achilles tendon rupture[4].

Matles Test: With the patient in prone position, the knees are flexed at 90 degrees. In a complete Achilles tendon rupture, the affected foot tends to be more neutral or dorsiflexion than the contralateral foot. Although the clinical diagnosis of Achilles tendon rupture is often reliable, imaging tests are useful, especially in cases of partial ruptures or when clinical findings are inconclusive[5].

Ultrasound is a valuable and widely available diagnostic tool that allows direct visualization of the Achilles tendon. It can identify disruptions in tendon fibers, intratendinous hematomas, and the extent of the rupture. In addition, dynamic ultrasound can assess residual tendon function during muscle contraction[6].

MRI is the gold standard for diagnosing Achilles tendon ruptures, especially in complex injuries or when surgical intervention is planned. MRI provides detailed images of tendon anatomy, allowing the evaluation of rupture extent, the degree of tendon retraction, and the condition of surrounding tissues. It is particularly useful in identifying partial injuries and planning surgery [7].

Although plain radiography does not directly visualize the Achilles tendon, it may be useful to exclude associated fractures, such as calcaneal fracture, or to detect bone avulsions that may be present in acute tendon injuries[8].

Treatment options

Managing Achilles tendon rupture involves choosing between conservative and surgical treatment, both with advantages and disadvantages. The therapeutic decision

depends on several factors, including the patient's age, level of physical activity, extent of injury, and individual preferences. Treatment choice should be guided by a careful risk-benefit assessment, considering long-term functional outcomes and potential complications[9].

Conservative or non-surgical treatment involves immobilizing the affected limb to allow natural tendon healing. This approach is often indicated for less active or elderly patients, for whom the surgical risk is high or in cases of partial injuries[10].

Traditionally, conservative treatment consisted of immobilizing the ankle in an equine position (plantar flexion) for six to eight weeks, followed by rehabilitation. However, more modern approaches use walking boots or functional casts that allow progressive adjustments of the ankle position, facilitating early controlled movement and tendon healing[11].

Recent studies suggest that early mobilization under protection, rather than prolonged immobilization, can improve functional outcomes and reduce recovery time without increasing the risk of re-rupture. Rehabilitation protocols that include stretching and progressive strengthening exercises are critical to restore tendon function and prevent muscle atrophy[12].

Conservative treatment has been associated with slightly higher re-rupture rates compared to surgical treatment, although the difference is minimized with early rehabilitation protocols. However, the absence of surgical scars and the lower incidence of surgery-related complications, such as infections and adhesions, are significant advantages of this approach[13].

Surgical treatment is generally recommended for young, active patients or athletes who wish to return to a high level of physical activity. Surgery is considered effective in reducing the risk of re-rupture and restoring the strength and function of the Achilles tendon[14].

Surgical Achilles tendon repair can be accomplished through open or minimally invasive approaches. In the open technique, the surgeon makes a larger incision to expose and suture the ruptured tendon ends. Alternatively, minimally invasive techniques, such as percutaneous repair, use smaller incisions and special instruments to suture the tendon, resulting in a lower risk of infection and smaller scars[15].

Postoperative management involves initial ankle immobilization in plantar flexion, followed by a progressive rehabilitation protocol. Early mobilization is encouraged in modern protocols, aiming at rapid functional recovery and return to physical activity. Although surgery reduces the risk of re-rupture, it is not without complications. Potential complications include infection, wound healing problems, adhesions, and nerve injury. The surgeon's experience and the proper selection of patients are crucial to minimize these risks[8].

Studies show that surgical treatment offers better results regarding tendon strength and return to pre-injury activity levels, especially in athletes. However, the difference from conservative treatment tends to be small when modern early rehabilitation protocols are used[10].

Considering the patient's profile and expectations, the choice between conservative and surgical treatment must be individualized. Although surgical treatment is preferred for active patients who require complete recovery of strength and function, conservative treatment is a viable option for patients with less physical demand or who wish to avoid the risks associated with surgery[9].

Recent advances in treating Achilles tendon rupture include biological repair techniques, such as applying growth factors and ECM grafts, which aim to improve tendon healing. In addition, new immobilization devices that allow early mobilization are being developed to optimize functional recovery[15].

Rehabilitation protocols

During the first few weeks after injury or surgery, the goal is to protect the tendon from excessive stress and allow healing to begin. At this stage, the ankle is usually immobilized in a plantar (equine) flexion position using an orthopedic boot or cast. The weight-bearing on the affected limb can be limited or adapted with crutches. Active plantar flexion and dorsiflexion movements are avoided to protect tendon repair[11].

At this stage, protected mobilization is initiated to prevent stiffness and promote targeted healing of the collagen fibers. The immobilization position is gradually adjusted to allow for greater dorsiflexion. Passive and active assisted range of motion exercises focus on controlled dorsiflexion and plantar flexion movements. Partial weight-bearing may be allowed, progressing to full load as healing progresses[14].

At this stage, emphasis is placed on restoring strength and beginning functional activities. Isometric and isotonic strengthening exercises are introduced for the calf muscles, gradually progressing to more challenging exercises such as heel lifts. The full range of motion of the ankle is slowly restored, and the full-weight-bearing should be achieved. Agility and proprioception movements are also incorporated to improve neuromuscular control[13].

The final phase of rehabilitation focuses on preparing the patient to return to normal and sporting activities. Plyometric exercises, strength and resistance training, and activities specific to the patient's sport or occupation are progressively introduced. The goal is to ensure that the patient fully regains tendon function with comparable strength and flexibility to the unaffected side. Return to sport is normally allowed between four to six months after injury or surgery, depending on individual recovery[16].

The modern approach to Achilles tendon rehabilitation favors early mobilization under protection, challenging the traditional practice of prolonged immobilization. Studies have shown that early mobilization can reduce the risk of joint stiffness, accelerate functional recovery, and improve the quality of tendon healing without significantly increasing

the risk of re-rupture. This approach is now widely adopted in both conservative and surgical protocols, with the adaptation of immobilization and weight-bearing according to the clinical progression of the patient[12].

Physiotherapy plays a central role in rehabilitating the Achilles tendon, providing expert guidance for each phase of the recovery process. An experienced physical therapist can adjust exercises and activity progression to avoid complications, such as re-rupture or adhesion formation while promoting proper healing. Regular clinical monitoring is essential to assess patient recovery, adjust the rehabilitation protocol as needed, and detect any signs of complications early[17].

Rehabilitation can vary between athletes and non-athletes, with specific adaptations to meet the functional demands of each group. In athletes, rehabilitation tends to be more intensive and focused on returning to high sports performance, including sports-specific training, advanced plyometric exercises, and future injury prevention strategies. In contrast, for non-athletes, rehabilitation may focus more on restoring function to daily activities and preventing re-rupture, with a more conservative pace of progression[16].

Prevention of re-rupture and other complications, such as chronic tendinopathy or persistent muscle weakness, is a crucial goal of rehabilitation protocols. Adherence to a structured and personalized rehabilitation program and ongoing medical follow-up are critical to ensuring a full recovery. Even after returning to normal activities, patient education about continuous rehabilitation is essential to prevent relapses and optimize long-term outcomes[18].

Complications and prognosis

Although a treatable injury, Achilles tendon rupture may be associated with several complications that influence the patient's prognosis. Proper management of these complications is essential to optimize functional outcomes and ensure complete recovery. The prognosis of the injury depends on several factors, including the type of treatment, adherence to the rehabilitation protocol, and the presence of comorbidities[17].

One of the most feared complications after Achilles tendon surgical repair is infection, which can range from superficial to deep. Deep infections can compromise the integrity of the tendon suture, leading to re-rupture or tendon necrosis. The prevention of infections involves rigorous aseptic surgical techniques and adequate postoperative wound care[19].

Complications such as wound dehiscence and formation of hypertrophic or keloid scars may occur, particularly in patients with risk factors such as diabetes or poor circulation. These complications may delay rehabilitation and require additional interventions, such as surgical revision or healing therapy[18].

The formation of adhesions around the repaired tendon can limit the ankle's range of motion and affect muscle function. Early mobilization and targeted rehabilitation techniques are crucial to minimize the risk of adhesions. Injuries to the posterior sural or tibial nerves may occur during surgery, resulting in painful neuropathies or paresthesias in the affected area. Although rare, these injuries can be debilitating and require specialized treatment, including pain management therapy[19].

The main complication associated with conservative treatment is tendon re-rupture, especially if the immobilization and rehabilitation protocol are not strictly followed. Studies indicate that early mobilization with adequate protection can reduce the risk of re-rupture, compared to prolonged immobilization[20].

Patients treated conservatively may experience residual weakness or functional deficit compared to the contralateral side, particularly in activities that require explosive force, such as running or jumping. Strengthening protocols and prolonged rehabilitation are essential to improve functional outcomes[21].

Some patients may develop chronic tendinopathy, persistent pain, and inflammation, even after tendon healing. This condition may result from improper healing or altered ankle and foot biomechanics. Management involves physiotherapy, activity modifications, and, in some cases, additional interventions such as platelet-rich plasma (PRP) injections[22].

The prognosis after an Achilles tendon rupture depends on several factors, including the patient's age, the level of physical activity before the injury, and the type of treatment received. Most patients can regain Achilles tendon function with appropriate treatment and intensive rehabilitation. However, the return to full sports ability may take six to 12 months, depending on the injury's severity and the treatment response [23].

The rate of Achilles tendon re-rupture is generally lower in surgically treated patients, especially compared to conservative treatment. However, with modern rehabilitation protocols, the difference in re-rupture rates between the two treatment methods has decreased significantly[24].

Post-injury quality of life may be affected by the complications above. Patients suffering from complications such as residual weakness, chronic pain, or infections may face ongoing challenges in their daily and sporting activities[25].

Athletes and physically active individuals wishing to return to high-impact sports may encounter challenges in recovery. Success in this return depends on extensive rehabilitation and the absence of significant complications. Rehabilitation directed towards sport and gradual reintegration is essential to prevent new injuries[26].

Strict adherence to the prescribed rehabilitation protocol is a major determinant of success in treating Achilles tendon rupture. Patients who follow medical guidelines tend to have better functional outcomes and a lower risk of complications. Conditions such as diabetes, obesity, and vascular disease can compromise tendon healing and increase the risk of post-treatment complications. Proper management of these comorbidities is essential to improve prognosis[27].

In cases of surgical treatment, the surgeon's experience and the choice of surgical technique are critical factors that influence the results. Experienced surgeons are more likely to avoid intraoperative complications and achieve durable repairs.

Effective management of complications associated with Achilles tendon rupture and adoption of evidence-based rehabilitation protocols are critical to optimize patient prognosis. Although conservative and surgical treatment can lead to good functional outcomes, the treatment choice should be personalized, considering the individual characteristics and the associated risk factors. Complete recovery is possible with careful planning and a multidisciplinary approach that includes surgery, physical therapy, and continuous clinical follow-up[28].

Recent advances and innovations in treatment

In recent years, the treatment of Achilles tendon rupture has evolved significantly, driven by technological advances, new surgical approaches, and the development of more effective rehabilitation techniques. These advances aim to improve clinical outcomes, reduce recovery time, and minimize injury-associated complications. The following discusses some of the major advances and innovations transforming the treatment of Achilles tendon rupture[28].

Percutaneous Achilles tendon repair is a surgical technique that involves making small incisions along the ruptured tendon, allowing suturing of the extremities without needing a large incision. Compared to open surgery, this technique has been associated with lower complication rates, such as infections and healing problems. In addition, percutaneous repair better preserves local vascularization and reduces the risk of adhesion[21].

Intraoperative ultrasound to guide Achilles tendon repair allows for accurate visualization of tendon structures, aiding in the correct placement of sutures and minimizing the risk of injury to adjacent structures. This approach can improve surgical outcomes and reduce re-rupture rates[25].

Biological therapies, such as applying growth factors and PRP, have gained prominence in treating tendon injuries. These substances are used during surgery or rehabilitation to promote tendon healing, accelerate recovery, and improve the quality of scar tissue. Preliminary studies suggest that PRP may reduce recovery time and improve functional outcomes, although more research is needed to establish standardized protocols[8].

Another promising innovation is using ECM grafts to enhance Achilles tendon repair. These grafts, composed of collagen and other structural proteins, can be implanted during surgery to provide additional tendon support and promote tissue regeneration. ECM has shown a potential to improve the resistance of the repaired tendon and reduce the risk of re-rupture[23].

Modern immobilization devices such as adjustable walking boots and dynamic orthotics replace traditional rigid immobilization methods. These devices allow for gradual adjustments in ankle position, facilitating early mobilization and promoting more functional tendon healing. The gradual transition to full-weight-bearing is an important feature of these devices, which helps reduce recovery time and improve functional outcomes[2].

The development of accelerated rehabilitation protocols, which promote early mobilization under protection and progressive strengthening exercises, has challenged the traditional paradigm of prolonged immobilization. These protocols have successfully reduced recovery time, minimized muscle atrophy and improved the quality of tendon healing. Rehabilitation guided by experienced physiotherapists is essential for the success of these programs[15].

Wearable devices such as motion sensors and smart footwear enable continuous monitoring of ankle mobility and weight-bearing during rehabilitation. These devices provide real-time data that can be used by physical therapists and physicians to adjust the rehabilitation protocol according to the patient's recovery, preventing complications and optimizing the return to activity[7].

Prevention programs focusing on neuromuscular training and strengthening calf and ankle muscles are gaining relevance, especially for athletes and active individuals. These programs aim to improve proprioception and motor control, reducing the risk of primary and recurrent Achilles tendon injuries[24].

Continued research in biomaterials, cell therapies, and tissue engineering promises to bring new approaches to treating Achilles tendon rupture. The development of artificial tendons and the application of stem cells for tissue regeneration are promising areas that, in the future, may revolutionize the treatment of this injury[28].

Conclusion

Achilles tendon rupture is a challenging injury that requires a carefully considered therapeutic approach to optimize clinical outcomes. The ongoing debate between surgical and conservative treatment reflects the complexity of clinical decision-making, highlighting the need to personalize treatment based on the individual characteristics and the specificities of the injury. Although surgical treatment has traditionally been preferred due to lower re-rupture rates, recent advances in minimally invasive techniques and accelerated rehabilitation protocols are changing the therapeutic scenery.

Innovations such as biological therapies, ECM grafts, and functional immobilization devices offer new opportunities to improve functional outcomes and reduce complications associated with the treatment of Achilles tendon rupture. However, the lack of consensus on the effectiveness of these approaches and the variability in clinical outcomes point to the need for more robust and high-quality studies.

Prospects are promising, with research focused on personalizing treatment, applying cell and biomaterial therapies,

and developing wearable technologies for continuous rehabilitation monitoring. Integrating these innovations can improve patient recovery and prevent further injury, especially in high-risk populations such as athletes.

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