Diseases and injuries of the achilles tendon

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Table of contents

Summary

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The Achilles tendon is one of the strongest and biggest tendons in the human body. Even though this is the case, it is also one of the tendons in the human body that is most often injured or ruptured. There are four injuries that are most common to the Achilles tendon: Achilles tendinitis/tendinosis, paratenonitis, retrocalcaneal bursitis and rupture. Achilles tendinitis is a condition in which the Achilles tendon is acutely inflamed due to excessive overuse while tendinosis refers to an overused tendon that develops microtears in a chronic setting. Multiple etiologies might be at play in these diseases. Diagnosis of all four previously mentioned diseases is mainly done clinically but can be aided by plain radiograph, ultrasound and MRI. Paratenonitis is a condition that can be seen in runners and is an inflammation of the sheath that surrounds the Achilles tendon. Treatment is mainly conservative and very rarely operative to remove adhesions. Retrocalcaneal bursitis is a condition in which the retrocalcaneal bursa gets inflamed which can cause it to hypertrophy and adhere to the Achilles tendon. This can lead to degeneration of the Achilles tendon. Treatment of this condition is mainly conservative but can also in rare cases be operative. Achilles tendon ruptures are divided into four types according to the Kuwada classification and are most often treated accordingly either conservatively or operatively. There is no clear consensus on the etiology of the ruptures but there are multiple theories such as a previous insult or a diminution of blood supply in an older age.

Keywords: Achilles tendon, injury, tendinopathy, rupture

Sažetak

Naslov: Bolesti i ozljede Ahilove tetive

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Ahilova tetiva je jedna od najjačih i najvećih tetiva u ljudskom tijelu. Unatoč tome, također je jedna od tetiva koja se najčešće ozljeđuje ili pukne. Postoje četiri ozljede koje su najčešće kod Ahilove tetive: Ahilov tendinitis/tendinoza, paratenonitis, retrokalkanealni burzitis i ruptura. Ahilov tendinitis je stanje u kojem je Ahilova tetiva akutno upaljena zbog pretjeranog prenaprezanja, dok se tendinoza odnosi na preopterećenu tetivu koja razvija mikro-rupture u kroničnom stanju. U ovim bolestima mogu biti prisutne različite etiologije. Dijagnoza svih četiri prethodno spomenute bolesti uglavnom se postavlja klinički, ali se može pomoći i rendgenskom snimkom, ultrazvukom i magnetskom rezonancom. Paratenonitis je stanje koje se može primijetiti kod trkača i upala je ovojnice koja okružuje Ahilovu tetivu. Liječenje je uglavnom konzervativno, a operativni zahvat se rijetko provodi kako bi se uklonile adhezije. Retrokalkanealni burzitis je stanje u kojem se retrokalkanealna burza upali, što može dovesti do hipertrofije i prianjanja uz Ahilovu tetivu. To može dovesti do degeneracije Ahilove tetive. Liječenje ovog stanja je uglavnom konzervativno, ali u rijetkim slučajevima može biti i operativno. Rupture Ahilove tetive se dijele u četiri tipa prema Kuwada klasifikaciji i najčešće se liječe konzervativno ili operativno prema potrebi. Nema jasnog suglasja o etiologiji ruptura, ali postoje različite teorije poput prethodne ozljede ili smanjenja dotoka krvi u starijoj dobi.

Ključne riječi: Ahilova tetiva, ozljeda, tendinopatija, ruptura

1. Introduction

The gastrocnemius and soleus muscles, sometimes referred to as the triceps surae form the Achilles tendon which inserts on the calcaneus. The triceps surae have an important function in both everyday walking and sports activities (1). This review paper aims to evaluate the most common Achilles tendon diseases and injuries. It will mainly focus on the etiology, diagnosis (clinical picture and different diagnostic modalities), classifications and treatment of the most common injuries and diseases affecting the Achilles tendon, namely, tendinitis, tendinosis, paratenonitis, retrocalcaneal bursitis and rupture.

2. Anatomy

On the posterior side of the leg the Achilles tendon can be found, a strong fibrous tissue that is formed by the tendons of the gastrocnemius and soleus muscles. The gastrocnemius originates from the medial and lateral condyles of the femur, more specifically, the origin of the medial head of the gastrocnemius is from the posterior surface of the medial supracondylar ridge and the adductor tubercle on the femurs popliteal surface. The lateral head of the gastrocnemius has its origin from the lateral condyle, more specifically from the lateral side of the condyle (2).

The soleus muscle has its origin on the dorsal side of the head and neck of the fibula. The soleus and the two heads of the gastrocnemius together form the triceps surae. The three heads of the triceps surae run inferiorly to form the Achilles tendon by the lower third of the tibia. This conjoined tendon of the two muscles inserts on the posterior side of the calcaneus, a point referred to as the calcaneal tuberosity. The gastrocnemius and soleus together have an imperative role in walking, running and jumping.

The most superficial muscle in the lower posterior leg is the gastrocnemius which covers the deeper lying soleus while together the triceps surae lie superficially to the deep muscles of the lower leg, more specifically, the tibialis posterior, the flexor digitorum longus, flexor hallucis longus and the popliteus.

The gastrocnemius and soleus get their main arterial supply from the sural arteries which are branches of the popliteal arteries. The soleus also receives some arterial blood supply from the fibular circumflex artery that in turn is formed by collateral

arteries of posterior tibial artery. The veins of the two muscles drain into the popliteal vein.

Innervation of the gastrocnemius and the soleus comes from the tibial nerve which itself is a branch of the sciatic nerve. The tibial nerve descends further and can be found medially to the Achilles tendon about 15 cm superior to the ankle (1).

The Achilles tendon receives its blood supply from two arteries, namely the posterior tibial and the peroneal artery. The Achilles tendon was found to have three different vascular sections which were determined by how much arterial supply each section had. The peroneal artery primarily nourishes the middle section of the Achilles tendon while the proximal and distal sections are mainly nourished by the posterior tibial artery. The middle section of the Achilles tendon was found to be most prone to rupture and have complications post-surgery due to hypovascularity compared to the proximal and distal sections. The study showed that people with inadequate blood supply to the midsection of the Achilles tendon were more prone to get tendon rupture (3).

The paratenon is a thin layer that covers the Achilles tendon and supplies it with blood and nutrients while the tendon itself is actually not vascularized and therefore is more prone to injury (4).

3. Biomechanics

The Achilles tendon is the tendon in the human body with the most tensile strength. It is the tendon responsible for tensing the triceps surae, and therefore making it possible to push the posterior part of the foot off the ground in order to complete tasks like walking, jumping and running (4). During exercise and normal daily loading, the Achilles tendon is exposed to a great deal of force. For example, when just

isometrically contracting the triceps surae, the force that the Achilles tendon is exposed to is around 3 kN while a simple exercise such as hopping on one leg exposes the tendon to 5 kN and running further exposes it to 9 kN. 9 kN would be the equivalent of around 900 kg of weight. Therefore, this puts into perspective how strong the Achilles tendon actually is (5).

4. Achilles tendon injuries

The Achilles tendon is the strongest tendon in the human body but in spite of this it is one of the tendons that gets injured most commonly (6). The most common injuries of the Achilles tendon are insertional Achilles tendinitis also known as tendonitis, Achilles tendinosis (Achilles tendinosis and tendinitis are sometimes together referred to as Achilles tendinopathy), paratenonitis, retrocalcaneal bursitis, Achilles tendon rupture and chronic Achilles tendon rupture (7). Achilles tendon injuries can occur in both people that lead a sedentary lifestyle and in people that lead a more active lifestyle such as professional sportsmen. Although these types of injuries and disorders are occurring in both populations, it is by far more frequent in athletic people. In a study conducted by Saini et. al. it was found that in the athletic community, the rate of occurrence of sudden tendon rupture was 8.3% over a person's lifetime, while chronic tendinopathy affected approximately 23.9% of athletes. In comparison, in the general population, the prevalence of acute tendon rupture was 5.9%, and chronic tendinopathy affected around 2.1% of individuals (4). Achilles tendon ruptures are more common in men than in women and according to a study by J. Lemme et. al., the highest occurrence of AT ruptures was observed among male patients aged 20-39 years, with a rate of incidence of 5.6 per 100,000 people in 1 year. Among female patients, the greatest incidence was observed in the age group of 40-59 years, with a rate of 1.2 per 100,000 people in 1 year (8).

5. Achilles tendinitis and tendinosis

Achilles tendinitis refers to the inflammatory process of the Achilles tendon where patients experience swelling, pain and irritation which causes a decrease in functional ability. Achilles tendinitis is considered to be an acute process caused by excessive strain on the tendon (9).

One should discriminate between Achilles tendinitis and Achilles tendinosis. In contrast to Achilles tendinitis, Achilles tendinosis refers to an overuse process in a chronic setting which causes microtears and finally results in degeneration of the Achilles tendon. Therefore, one could say that Achilles tendinosis is the result of an improperly cared for tendinitis (10).

Achilles tendinitis can be further divided into insertional and noninsertional tendinitis. Noninsertional Achilles tendinitis is a condition that is more often prevalent in the younger population, predominantly in more athletic people. It is most notably seen in the young runners (9). Noninsertional Achilles tendinitis is differentiated from insertional tendinitis by the location of where the pathological process is going on. In insertional tendinitis, the point of inflammation is the point of attachment of the tendon to the calcaneus while in noninsertional tendinitis, the inflammatory changes are present a few centimeters superiorly to the point of insertion of the Achilles tendon (10).

It is unclear exactly what causes noninsertional Achilles tendinosis. There are numerous theories, indicating that it is probably a complicated process impacted by a number of variables. These variables can include anything such as steroid use, fluoroquinolone medications, improper training methods, environmental factors,

footwear preferences, age, gender, body mass index, biomechanical abnormalities, foot malalignment, instability in the talocrural joint, excessive use without proper rest, etc. (11).

Patients with insertional Achilles tendinopathy frequently report stiffness that becomes worse after extended periods of inactivity and discomfort that gets worse with movement. These symptoms frequently limit their capacity to perform work and engage in sports activities. Furthermore, many people have trouble finding footwear that fits because of increased sensitivity in the posterior heel.

The characteristic feature of insertional Achilles tendinosis is the presence of degenerative changes within the Achilles tendon insertion point. Loss of a parallel collagen structure, weakened fiber integrity, lipid infiltration, and enhanced capillary development are the hallmarks of tendon degeneration (12,13). Imaging studies have shown that this degeneration is characterized by the tendon's aberrant appearance and increased thickness. Insertional Achilles tendinosis is frequently diagnosed using a diagnostic criteria of tendon thickness more than 6 mm (11,14–16).

A grading system for MRI-based assessments of Achilles tendon pathology was developed by Nicholson et al. (11,16), and it was discovered to be related to the prognosis of conservative therapy. The grading system was dependent on two variables; tendon diameter and the presence of degeneration within the tendon. The grades and criteria were: Grade I: Anteroposterior diameter ranging from 6 to 8 mm with nonuniform degeneration, Grade II: Tendon diameter greater than 8 mm with uniform degeneration affecting less than 50% of the tendon width. Grade III: Tendon diameter greater than 8 mm with uniform degeneration affecting more than 50% of the tendon width.

According to the study, individuals with Grade I tendon pathology had a significantly lower likelihood of requiring surgery (13%) compared to those with Grade II (91%) or Grade III (70%) pathology. This indicated that less severe cases, categorized as Grade I, had a higher chance of responding well to conservative treatment approaches (11,16).

Patients with noninsertional Achilles tendinopathy typically feel discomfort that is localized 2 to 6 cm above the Achilles tendon insertion site, especially during activity. Exercise sessions typically have periods of increased pain at the beginning and end while the pain subsides somewhat during the exercise. When examining a patient with suspected injury to the Achilles tendon, the posterior part of the foot should be examined physically to look for things such as misalignment, deformity, tendon asymmetry, thickness, Haglund deformity, and prior scarring. Approximately 4 to 6 cm above the calcaneal insertion, the Achilles tendon may swell in a fusiform manner (10,17). The patient may as well be complaining of pain in the dorsal part of the heel, pain during movement, swelling, burning sensations, stiffness and pain while wearing shoes caused by the pressure. On physical examination one may also see a bony enlargement on the hindfoot or pain along the midline of the tendon (17).

The diagnosis of tendinitis and tendinosis is mainly made clinically but can be aided through various imaging methods. Mainly plain X-ray, ultrasound and MRI. Plain lateral X-ray radiographs in a standing position are useful for determining if the patient has bony abnormalities, calcifications or ossifications. In general, plain radiographs are taken for patients that have been symptomatic for 6 weeks or more. If a calcification of the posterior calcaneus is found on radiograph, then this is considered to be a confirmed diagnosis of insertional Achilles tendinopathy (18).

Both ultrasound and MRI can be used to aid in the diagnosis of Achilles tendinopathy. Ultrasound, although highly dependent on the expertise of the operator, is an excellent first line of imaging due to it being a cheap and fast modality that can recognize soft tissue changes such as degeneration or thickening of the tendon, neovascularization, bursitis, paratenonitis but also changes in the bone itself such as calcifications within the tendon or enthesophytes. MRI is similarly a good tool in aiding diagnosis of Achilles tendinopathy but should not be used as first line imaging. It can as ultrasound recognize changes in soft tissues such as the structure of the tendon and thickening. MRI is a great tool for discerning between tendinopathy and paratendinopathy. Although signs of tendinopathy can be seen on imaging, it does not necessarily mean that a patient will have Achilles tendinopathy or the other way around (11,18).

Treatment of Achilles tendinopathy is not as straightforward as it might seem. To this day, there have not been enough major studies to form guidelines concerning the treatment of Achilles tendinopathy. Albeit, it is a general consensus that first line treatment should be conservative. A patient should have had symptoms for at least 6 months in order for surgery to be considered.

Due to a lack of evidence, there is no consensus on what conservative management should look like. So far, there has only been strong evidence in favor for eccentric training. Although still not fully understood, eccentric exercise of the Achilles tendon has been shown to be beneficial in the rehabilitation and conservative treatment. It is believed that one mechanism of action of eccentric training could be that it destroys the neovascularization that occurs after injury (10,11). Eccentric exercises that allow full range of motion of the Achilles tendon have shown poor results with patients while

an exercise where the range of motion is shortened so that the heel lowers just past the neutral position of the ankle has shown more satisfactory results with patients (11).

NSAIDs are a group of medications that are often prescribed by physicians and used for pain relief in the setting of Achilles tendinopathy but their effect on the healing process is not completely understood since it has been shown by some studies that these drugs could potentially cause impaired healing due to their effects on cytokines and cell proliferation (10).

Around 24% to 45% of patients do not respond to or have unsuccessful results with conservative management after 6 months (19). These patients should therefore be considered for operative management. There are a multitude of operative procedures for insertional Achilles tendinopathy, most of which aim to cause minor trauma to the diseased portion of the tendon in order for a healing process to initiate. The other most common procedures aim to remove a part of the Achilles tendon that is pathological. One surgical method used to induce minor trauma in the Achilles tendon is the percutanous scraping of the tendon guided by ultrasound. This method has shown a significant rate of success during the 1-2 year follow-up period (10,20,21).

Operative treatment of the insertional Achilles tendinopathy usually aims to remove the diseased part of the tendon, calcifications, the posterosuperior calcaneal prominence or the retrocalcaneal bursa (11). There is no consensus on how much of the Achilles tendon insertion can be debrided but one study found that upwards of 50% of the insertion could be removed without serious complications of that procedure (11,22). In cases where more than 50% of the Achilles insertion has to be removed, it has been advised to use double row fixation to fixate the tendon (11,23,24).

6. Achilles paratenonitis

Paratenonitis or peritendinosis as it was called before is the denotation for the inflammation of the membrane like tissue that envelops tendons that do not have synovial sheats (7). The paratenon has two functions, partly to allow for free frictionless movement of the tendon against other structures and partly to nourish the Achilles tendon through its vascularization (25). This pathology can often be seen in younger individuals that do long distance running. The Achilles tendon is enveloped by a paratenon that can most often get inflamed together with the actual Achilles tendon but it can also get inflamed independently from the Achilles tendon. When looking at the paratenonitis on histology, capillary growth and inflammatory cells can be seen. The problem that arises from paratenonitis is that myofibroblasts in the paratenon start producing collagen which causes the paratenon to narrow and thereby decreasing the blood supply to the Achilles tendon (7).

The diagnosis of paratenonitits is done through clinical examination but can be assisted through ultrasound and MRI. Acute paratenonitis presents as a warm and soft tissue on palpation. While palpating the tendon, a grainy sensation can also point towards a diagnosis of paratenonitis (26). Patients also commonly complain of symptoms such as a tight gastrocnemius and soleus and a tender and swollen Achilles tendon. When diagnosing Achilles paratenonitis without tendinitis the thickening and tenderness stays fixated in one position during dorsiflexion and plantarflexion of the talocrural joint (7).

Treatment for this condition is mainly conservative and consists of either orthoses, boot braces or NSAIDs, ice and physical therapy. If adhesions are present between

the tendon and the paratenon, brisement is a procedure that has proven to be helpful (7,27). In rare cases, open or arthroscopic surgery could be used as a last resort to debride the adhesions between the paratenon and the Achilles tendon (7,28).

7. Retrocalcaneal bursitis

In-between the Achilles tendon and the calcaneus lies the retrocalcaneal bursa. The bursa is filled with fluid and its function is to lubricate the movement of the Achilles tendon against the calcaneus and therefore enable frictionless movement between the bone and tendon (29). In the case of retrocalcaneal bursitis, the bursa becomes inflamed and can hypertrophy which can cause it to adhere to the Achilles tendon. This in turn can lead to a degeneration of the Achilles tendon (7).

Retrocalcaneal bursitis is diagnosed through a combination of a clinical examination and imaging in the form of X-ray, ultrasound or MRI. Patients complain of pain slightly anteriorly of the insertion point of the Achilles tendon. During the clinical exam, when palpating medially and laterally to the Achilles tendon, pain will be provoked. Pain is also provoked with dorsiflexion. In order to exclude a bony prominence, a normal X-ray can be useful. Ultrasound or MRI on the other hand are used to visualize the soft tissues and look for inflammatory signs such as fluid or degenerative signs of the Achilles tendon (7,17).

Treatment of this condition is mainly conservative and consists of NSAIDs, foot braces and modifying activity and footwear. In rare cases, endoscopic or open surgery can be necessary to extract the bursa or possible bony prominences (7,17).

8. Achilles tendon rupture

Achilles tendon ruptures are mainly divided into acute and chronic ruptures (30). Chronic Achilles tendon ruptures are ruptures that are diagnosed or treated more than 6 weeks after the actual rupture. Therefore, a chronic rupture is tougher to treat than an acute one as the gastrocnemius and soleus muscles contract over time making the ends of the tendon retract and therefore making an end to end anastomosis harder (31).

The classification system most often used for Achilles tendon ruptures, namely the Kuwada classification divides the ruptures into 4 groups: Type 1: partial ruptures where less than 50% of the tendon is ruptured. These are most often treated conservatively with cast and immobilization for 6 to 8 weeks. Type 2: complete rupture with a tendinous gap of ≤3 cm. These are typically treated operatively with end-to-end anastomosis. Type 3: complete rupture with a tendinous gap of 3 to 6 cm which often require tendon or synthetic grafts. And lastly type 4 ruptures: complete ruptures with a defect of >6 cm also known as neglected or chronic ruptures. These often require tendon/synthetic grafts and gastrocnemius recession(32,33).

The etiology of Achilles tendon ruptures is still not known but there are some factors that are known to play a role, like inflammatory and autoimmune conditions, collagen abnormalities, infectious diseases, fluoroquinolones, systemic or injectable steroids, repetitive microtrauma, tendon variations, decreased blood flow in older patients, abnormal pronation and mechanics, ankle equinus, and Achilles calcification (34). The most common mechanism of injury is due to rapid dorsiflexion of a plantarflexed foot (35). Different hypotheses have been proposed concerning the etiology of Achilles tendon ruptures and some researchers have proposed that the etiology can

be either mechanical or vascular. The mechanical theory suggests that the Achilles tendon has previously been exposed to some type of injury from which it did not heal completely and therefore got weaker causing it to eventually rupture. The vascular theory on the other hand proposes that increasing age of a patient or previous trauma causes a diminution of the capillary vessel supplying the Achilles tendon which in turn leads to a degenerated tendon (34,36,37). Achilles tendon ruptures are more frequent in men(more than double the likelihood of women) and people between the ages of 30-40 years and people over the age of 60 (30,35). Multiple studies have shown that Achilles tendon injuries, including ruptures are more common in runners, where some studies have shown that Achilles tendon injuries have been symptomatic in anywhere from 7-29% of runners and in some papers these numbers have been even higher (34,38,39). However, when examining ruptured Achilles tendons through histopathological studies, it becomes apparent that nearly all of these individuals exhibit evident degenerative alterations. These include conditions such as hypoxic and mucoid degeneration, inadequate blood supply, tissue and cell death, calcification, tendolipomatosis, and also irregular and deteriorated collagen fibers in and around the ruptured area (40–44).

The diagnosis of Achilles tendon ruptures is made clinically with an adequate patient history but can also be aided by ultrasound and MRI. The patients will often complain of having felt like being kicked in the back of the leg or heel and hearing a loud popping sound, sometimes described as sounding like a gunshot (30,45). Furthermore, the patients might have problems walking uphill or walking up the stairs (44). On physical examination, the physician can sometimes see an atrophied leg compared to the contralateral side. The physician can also often palpate a gap in the Achilles tendon (46). The clinical test that is often used and that has the highest

sensitivity is the Thompson test in which patients lie on their belly while the feet of the patient are hanging of the edge of the table. The physician then grabs hold of the muscles of the posterior leg, meaning the triceps surae muscles and squeezes in order to produce an “artificial” contraction of the triceps surae and thereby causing the Achilles tendon to slide superiorly towards the squeezed muscles. In a normal non injured foot, this action would cause the foot to plantarflex to the contraction of the triceps surae. In a ruptured Achilles tendon, the plantarflexion of the foot will be absent proving the Thompson test to be positive (44,47). In about 25% of cases, Achilles tendon ruptures do not get the correct diagnosis (30,34,48).

In order to ensure a more accurate diagnosis, ultrasound and MRI can be used. These modalities are also very helpful in diagnosing partial and chronic ruptures which in general are harder to diagnose than the frank Achilles rupture. Ultrasound is a very cost-effective modality for diagnosing Achilles tendon ruptures and is also a good tool for measuring the gap between the ends of the tendon (34,49,50). When examining a healthy Achilles tendon using ultrasonography, one can observe hypoechogenic bands of parallel fibrillar lines positioned between two hyperechogenic bands in the longitudinal view. In the transverse view, these bands exhibit a round or oval shape. Conversely, ultrasonographic images of a ruptured tendon reveal a disrupted fibrillar pattern, a gap between the torn ends, and an absence of acoustic signals (34). Detecting partial tears with ultrasound may be more challenging. When examining a partial tear with ultrasound and doppler it reveals an area where the superficial tendon line appears irregular and protruding, often accompanied by increased blood flow in that area. In the cases where ultrasound does not give a certain diagnosis, MRI can be used. MRI will in these cases demonstrate a bright signal in the tendon on T1 and T2-weighted sequences (51).

The treatment of Achilles tendon ruptures can be either conservative or operative. There is still a lack of consensus regarding whether conservative treatment or operative treatment is the better option. Previous studies have showed that the risk for rerupture was higher in patients that had been treated with conservative management compared to those that had operative treatment while those that had operative treatment had more complications in the form of postoperative infections, anesthesia and other complications related to surgery (52,53). Newer studies have showed that cases of rerupture decrease to a number comparable to that of operative treatment if the time of immobilization by casting is decreased and early functional rehabilitation is started (52,54).

For type I ruptures, that is, ruptures that are partial with less than 50% of the Achilles tendon ruptured the most common form of treatment is conservative. The conservative treatment of Achilles tendon rupture consists of 6-8 weeks of immobilization of the foot in a brace or cast. The first 4 weeks, the foot is placed in a plantarflexed position in order for the ruptured ends of the Achilles tendon to oppose. The next 2-4 weeks, the foot is put in a neutral position. However, following the recommendations of newer studies that show that risk of rerupture is lowered by earlier functional rehabilitation, meaning that the duration of casting/bracing could be lowered (52,54,55).

Achilles tendon ruptures can be treated by different surgical methods. The surgical method chosen for a repair depends on the type of rupture based on the Kuwada classification system (33,35).

If the rupture is a type II, meaning that the rupture is complete and that the gap between the tendons ends is less than 3 cm long, the most common form of repair is end to end. This type of repair is done under general, regional or local anesthesia. An incision that is 6-10cm long is usually made centrally along the midline of the Achilles tendon or alternatively posterior-medially along the midline. The latter is recommended in order not to cut the sural nerve. Further, the dissection moves through the fat and subcutaneous tissue with minimal cutting or severing until the crural fascia and the tendon above it are exposed. At this point the crural fascia and paratenon can gently be cut and pulled to the side so that the exposed tendon can be reached. Now the hematoma can be removed. The area should then be debrided and properly cleaned prior to pulling the tendon ends together to align them (34). In this and all other surgical techniques, the surgeon should stretch the Achilles tendon in order to get it back to its original length. The original length can be ascertained by comparing to the plantaris tendon but in some cases, this can also be done by comparing the Achilles tendon of the leg that is being operated on to the one that is healthy (34,52). Furthermore, the suturing of the two ends of the tendon can be done by Bunnel, Kessler or Krackow techniques but studies have shown that the Krackow technique has shown better biomechanical results (56,57). Lastly, the affected foot is compared to the other side before the paratenon, crural fascia and skin are closed up (34).

If the gap in a rupture is between 3 to 6 cm long, referred to as a type III rupture, this usually calls for surgical repair with some type of augmentation. This could be a synthetic or tendon allograft or autograft. Usually this is done with a plantaris tendon autograft due to the plantaris tendon being readily accessible from the already opened wound. The plantaris tendon can in this case be removed from the insertion

point of the calcaneal bone and spread out in order to then suture it onto the two tendon ends. When using synthetic grafts, the Achilles tendon is enveloped into the grafts which is then sutured to the tendon (34).

When a rupture has been neglected 4 to 6 weeks and the gap is bigger than 6 cm long, meaning that it's classified as a type IV rupture or also known as a chronic rupture, this type of rupture will usually have to be treated surgically with gastrocnemius recession and a tendon or synthetic graft. However, there are no guidelines in place that determine if this should be the method of treatment in all chronic Achilles tendon ruptures. Like mentioned earlier, the most widely used tendon for autograft is the plantaris tendon but in many cases of chronic ruptures, the plantaris tendon cannot be used due to adhesions and scarred tissue and can therefore not be easily identified. Other tendons that can be used are peroneus brevis, flexor digitorum longus and flexor hallucis longus. Furthermore, V-Y lengthening is a surgical technique developed by Abraham and Pankovich in which the Achilles tendon is lengthened and allows for closure of gaps that are 6 cm long at most (34,58).

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11. Biography

Edin Alibegovic was born in Solna county in Stockholm, Sweden on the 26th of February 1998. He attended elementary school and high school in his home city of Växjö, Sweden. His father is a gastric surgeon so due to this he became interested in medicine early on in his life. In 2017, he enrolled into the School of Medicine, University of Zagreb in the international program. During his studies he developed an interest for the surgical field, especially orthopedics and trauma surgery.