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Review

# Current Concepts in the Management of Achilles Tendon Injuries

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## Abstract

Achilles tendon injuries are commonly encountered in orthopaedic practice. The Achilles tendon is prone to rupture, and this negatively imparts ambulation. The diagnosis is clinical. Treatment options have evolved from conservative to surgeries, however there is no consensus on the most superior option of treatment. This narrative review aims to highlight the evolution in clinical diagnosis and treatment of Achilles tendon ruptures and discuss the current evidence in the treatment with emphasis on outcome measures of each treatment modality. Relevant studies on Achilles tendon ruptures with emphasis on treatment options, their strengths and weaknesses were reviewed. The treatment of Achilles tendon rupture has evolved from conservative options to surgeries. The surgical options include open repair, percutaneous repair, endoscopic repair, and ultrasound-guided repair. However, there is still no consensus on the most superior option for treating Achilles tendon injuries. Each method has its pros and cons. Conservative treatment has the appeal of the absence of scars, low cost and shorter duration of hospital stay. However, ankle stiffness, and late return to work are important drawbacks. Open surgery has the advantage of early return to function and low re-intervention rates. Surgical scars, likelihood of infection and cost are major disadvantages. Appropriate patient selection guided by the severity of the injury, the age of the patient, pre-injury status, work demand for the patient, experience of the surgeon, available resources, local soft tissue condition, and the patient's preferences are key to successful outcome.

**Keywords**: Achilles Tendon Injuries; Current Concepts; Management.

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## Introduction

The Achilles tendon is the strongest and thickest tendon in the body. It is also the most prone to rupture [1] because it plays key roles in all phases of the gait cycle, injuries of the Achilles tendon affect ambulation negatively. The tendon is formed by the terminal fibers of the gastrocnemius muscle and the soleus muscles running behind the ankle and sub-talar joints to attach to the calcaneus.

Achilles tendon rupture rates are the highest among all tendons in the body, accounting for one-fifth of all tendon ruptures [2]. Injuries to the tendon can typically be divided into high energy injuries, low energy injuries, and penetrating injuries. High energy injuries commonly occur during sports, especially those involving exertion of firm dorsiflexion to produce propulsive motion. These ruptures occur in an otherwise healthy tendon and are commonly seen in young people between age 20-45 years [3]. Low energy injuries commonly occur in tendons already diseased by degenerative conditions. These results from sub-optimal force applied repetitively on an already weakened tendon [4]and are common in patients 60 years and above.

Bicycle spoke injuries are the most common cause of Penetrating injuries to the Achilles tendon. Guptha and Shrestha [5] typically described these injuries as those occurring on back-seated passengers on the bicycle who sit with legs dangling out on either one or both sides of the wheel. The unprotected and unsupported limbs get caught in the spokes of the cycling wheel resulting in varying degrees of injuries affecting the Achilles tendon and other structures around it. These injuries typically pose a serious treatment challenge to the orthopaedic surgeon. Other forms of penetrating injuries include gunshot injuries, stab injuries, and shrapnel injuries.

Diagnosis of Achilles tendon injuries is clinical. The triad of inability to toe-stand on the affected limb, marked tenderness around the Achilles and the palpation of a defect along the original course of the tendon gives the diagnosis in 90% of cases. Ultrasonography is playing an increasing role in patients that have a false- negative Thompson's test and for minimal access repairs of a ruptured tendon. Plain radiography is utilized when avulsion injures are suspected.

Though treatment options have evolved from conservative options to open surgeries to minimally invasive repairs, there is still no consensus on the most superior option for treating ruptures from closed injuries.

This paper aims to highlight the evolution in clinical diagnosis and treatment of Achilles tendon ruptures and discuss the current evidence in the treatment. In this narrative review, we examined the various repair techniques for Achilles tendon injuries, with focus on the strength of outcomes and complications.

Our literature review was conducted using PubMed and Google Scholar search, focusing on clinical trials, observational studies, cohort studies, systematic reviews, and meta-analyses from 1950 to 2025. The search employed the following keywords: "open repair," "repair techniques," "Kessler's repair," "percutaneous repair" "Achilles repair," and "non-operative treatment." All articles were restricted to the English language. Further relevant articles were identified through manual cross-referencing of the literature. Case reports were excluded.

## Anatomy

The Achilles tendon is formed by the terminal fibers of the gastrocnemius (originating from the distal femur) and the soleus muscle (originating from the proximal tibia). The tendons spiral down in an atypical manner, with the gastrocnemius fibres attaching themselves at a perpendicular angle to the centrally placed fibres from the soleus muscle.

Historically, Philip Verheyen was the first to describe the tendon in his book *Corporis Humani Anatomia*, in 1693. he called it the "tendo Achilles," [6] a phrase still used by many authors in modern day texts. Phillip's terminology replaced that used by Hippocrates earlier in a bid to define it as the big tendon of the body, "tendo magnus" [6]. Ambroise Paré's work of the 16th century was the first to describe injuries to the tendon with specific details on symptoms and signs and prognostic predictors [7].

The blood supply to the proximal and distal sections of the tendon is by the posterior tibial artery while the peroneal artery supplies the midsection (2 to 6 cm from the insertion point) this portion of the tendon which receives a relatively poor blood supply, is most vulnerable to rupture. More recent evidence shows that the diameter of the posterior tibial artery is larger than that of the peroneal artery validating the poor supply to the mid distal segment of the tendon [8]. The tendon is also not covered in a tendon sheath but by a paratenon. The paratenon is highly vascularized which explains the possibility of tendon healing when fibres across ruptured ends are in contact with each other.

The tendon plays a pivotal role in ambulation, serving as a link between the ankle planter flexors and their attachment to the calcaneus. Rupture of this tendon therefore negatively impacts ambulation.

## Epidemiology

Achilles tendon rupture rates are the highest among all tendons in the body, accounting for one-fifth of all tendon ruptures[2]. Incidence ranges from 10-50 ruptures per 100,000 persons per year [9,10]. Two peaks have been observed epidemiologically. The first peak is between age 25-40years. This group usually has acute ruptures of otherwise healthy tendon from sports-related injuries and trauma [3,4]. The second peak occurs at age 60years and above, usually from low energy trauma in a tendon with pre-existing degenerative disease (tendinopathy) [3,4].

Risk factors for Achilles tendon ruptures include, male gender, involvement in high impact sports (jumping and running sports), preexisting degenerative tendon diseases, previous Achilles tendon injury, increasing age, previous steroid injections around the tendon and preexisting muscle atrophy [11,12,13,14]. More recent evidence shows that repetitive trauma to the tendon causes micro-ruptures that eventually become obvious with an acute incident [8]. Metabolic disorders like Diabetes mellitus and repeated steroid injections also increase the risk.

## Clinical Diagnosis

Typically pain around the tendon is accompanied by an acute rupture. Most patients recall a popping sound around the heel at the time of the acute event. In young patients, these complaints follow propulsive forces generated around the heel during take-off in sprints, high jumps, long jumps, and other sporting activities. In the elderly population, the forces are trivial but repetitive and the tendon is weak previously. Penetrating injuries give a straight history of trauma to the heel with a known implicating object.

The triad of inability to toe-stand on the affected limb, marked tenderness around the Achilles and the palpation of a defect along the original course of the tendon gives the diagnosis in 90% of cases.

Clinical examinations classically showed positive Thompson's test, decreased dorsiflexion, a palpable defect along the length of the Achilles tendon and patient's inability to stand on the toes on the affected foot.

Thompson's test also called Simmonds-Thompson's test or calf squeeze test [15,16] involve squeezing the calf muscles (soleus and gastrocnemius muscles) with the patient lying prone and the legs hanging out from the edge of the examination couch. In a positive test (indicating a ruptured Achilles tendon) the squeeze fails to produce ankle plantarflexion while in a negative test, the reverse occurs.

Though extremely sensitive, Thompson's test is not pathognomonic for ruptured Achilles tendon. False negatives have been reported with the test, especially in patients with incomplete rupture and those with chronic rupture from degenerative tendon disease. Patients with presumed false negative tests will require radiologic tests for diagnosis.

Matle's test, another highly sensitive test involves 90-degree flexion of the knee of a patient in prone position. The ankle fails to maintain plantigrade position and moves into dorsiflexion in a positive test. In a negative test (when the Achilles tendon is still intact) the ankle will be maintained in plantigrade position. Similar clinical scenarios like the Thompson's test will produce false negative results with the Matle's test too.

The palpation test relies on the detection of a gap along the anatomical course of the tendon with the patient lying prone. This may be hampered by swelling sequel to trauma and may present as a negative test when ruptures are incomplete.

O'Brien [[17] formulated the needle test for diagnosis of incomplete tendon rupture and localizing the point of rupture. The test involved inserting a 25G needle along the tendon, 10cm proximal to the calcaneal insertion of the Achilles. Passive ankle dorsiflexion will make the hub of the inserted needle move in a direction opposite the ankle motion. The drawbacks of the O'Brien's needle test are that it is invasive, adds to the pain of trauma, found to be of little clinical use and hence its sensitivity and specificity is still unknown.

Copeland [18] to provide a less invasive test for incomplete rupture and calibrate the residual strength of the dorsi-flexors proposed the sphygmomanometer test. With the patient lying prone, knee flexed to 90 degrees, the cuff of the sphygmomanometer is tied to the calf muscles and inflated to 100mmHg with the ankle in planter-flexion. Passive dorsiflexion of the ankle will raise the pressure in the mercury column by at least 40mmHg. The contralateral limb is usually used for comparison. This test has not found widespread usage.

## Imaging Modalities

Clinical parameters constitute the mainstay of diagnosis of Achilles tendon rupture. Imaging only plays the role of confirming diagnosis when presumed false negative exists. It also helps in assessing the extent of injury, follow-up of patients after treatment, diagnosing incomplete ruptures and detecting early risk of re-rupture.

Ultrasonography and Magnetic Resonance Imaging (MRI) have been reported to be quite useful in these regards [19,20,21]. Ultrasonography has particularly found useful roles as an outpatient procedure in localizing the injury, detecting its extent, and identifying calcification along the tendon tract. More recently USS-guided repairs have been reported with results showing less surgical dissection, no wound healing problems, and faster healing. Its major drawback is that it is user dependent.

MRI is more sensitive in detecting the severity of injury to the tendon and to surrounding soft tissues. It is however expensive and not available in some centers in tropical Africa.

## Treatment

There is no consensus on the treatment of Achilles tendon rupture [22,23]. Available treatment options include Conservative treatment, Open surgical repair, Percutaneous repair and USS-guided repairs.

Conservative treatment options have been reported to have better outcomes in acute ruptures in the younger population. Though surgical scar and wound infection is avoided, it has however been associated with higher re-rupture rates compared to surgical intervention and increased risk of joint stiffness and muscle weakness following prolonged immobilization [23].

Typically, conservative treatment involves above-knee cast immobilization with the ankle in maximum planter flexion for three weeks which is thereafter reduced to a below knee cast with the ankle in plantigrade position for another three to five weeks before commencement of full weight bearing. Serial immobilization with the ankle gradually moved to plantigrade position have also been reported [8].

Physical exercises involving calf muscle stretches, ankle range of motion exercise, calf muscle strengthening exercise and proprioception training can be commenced on removal of cast. Both Nilsson et al [24] and Olsson et al [25] in their separate randomized clinical trials showed that non-operative treatment had equivalent results with respect to patient-reported outcomes and physical performance compared to open surgical repairs.

Stale et al [26] in a recent multi-centered randomized trial on non-operative or open surgical repair of Achilles tendon rupture reported that the mean changes in the Achilles' tendon Total Rupture Score were −17.0 points in the nonoperative group, −16.0 points in the open-repair group, and −14.7 points in the minimally invasive surgery group (P=0.57). Pairwise comparisons provided no evidence of differences between the groups. The changes from baseline in physical performance and patient-reported physical function were similar in the three groups. Achilles tendon rupture scores are patient report outcome measures using ten questions evaluating the physical activity level and the changes in patient symptoms. Scores in each domain range from 0-10 with one hundred being the highest score. Higher scores indicate better health status and better outcomes. The acceptable minimal difference in score between pre-intervention and post-intervention state is 8-10 [27,28,29].

Their study however also found that the number of tendons re-ruptures were higher in the nonoperative group (6.2%) than in the open-repair or minimally invasive surgery group (0.6% in each) with the risk of re-rupture being 5.6 percentage points higher in the nonoperative group than in the open-repair group (95% CI, 1.9 to 10.2) and the minimally invasive surgery group (95% CI, 1.8 to 10.2).

In general, conservative treatment may be more suitable for patients with low work demand, patients not involved in active sports, those with concomitant injuries that require more urgent attention and patients whose medical condition excludes surgical intervention. In the tropics with low health insurance, it is a viable option for patients who cannot afford surgery.

**Open Surgery**

Open surgical intervention remains the most popular treatment especially for tendon ruptures resulting from degenerative disease, ruptures in high demand patients, in patients involved in active sports, in open injuries as well as in cases of re-rupture following conservative treatment. Open repairs restore tendon length (a classical requirement for restoration of tendon function), eliminate prolonged immobilization and consequent joint stiffness, allows early rehabilitation and restores tendon function.

Arner and Lindholm [30] have over 70 years ago reported good outcomes from open surgical repairs of Achilles tendon ruptures. A prospective randomized clinical trial by Cetti et al [31] (involving a total of 111 patients with acute Achilles tendon rupture) showed that open repair had lower rate of re-rupture (4%) than nonoperative treatment (13%), as well as a higher rate of return to previous sports or activities (58% vs. 29%, respectively).

Superficial and deep wound infection requiring reoperation have however been reported with this treatment modality [31,32].

Stale et al [28] have also reported nerve injuries (sural nerve) in 2.6% of their respondents in a multi-center randomized clinical trial. Open surgical repair of the Achilles tendon involves making a surgical incision through the medial para-tendon approach. Beyond the subcutaneous tissue, the paratenon is incised to expose the tendon whose torn edges are freshened and repaired using various techniques based on the surgeon's preferred choice and experience.

The Kessler's or modified Kessler's method involves passing two or more stitches through both ends of the ruptured tendon with anchors at both sides of the tendon proximal to the cut ends in a manner that pulls the two ends tightly together to achieve repair. This has been modified with more sutures and more knots introduced.

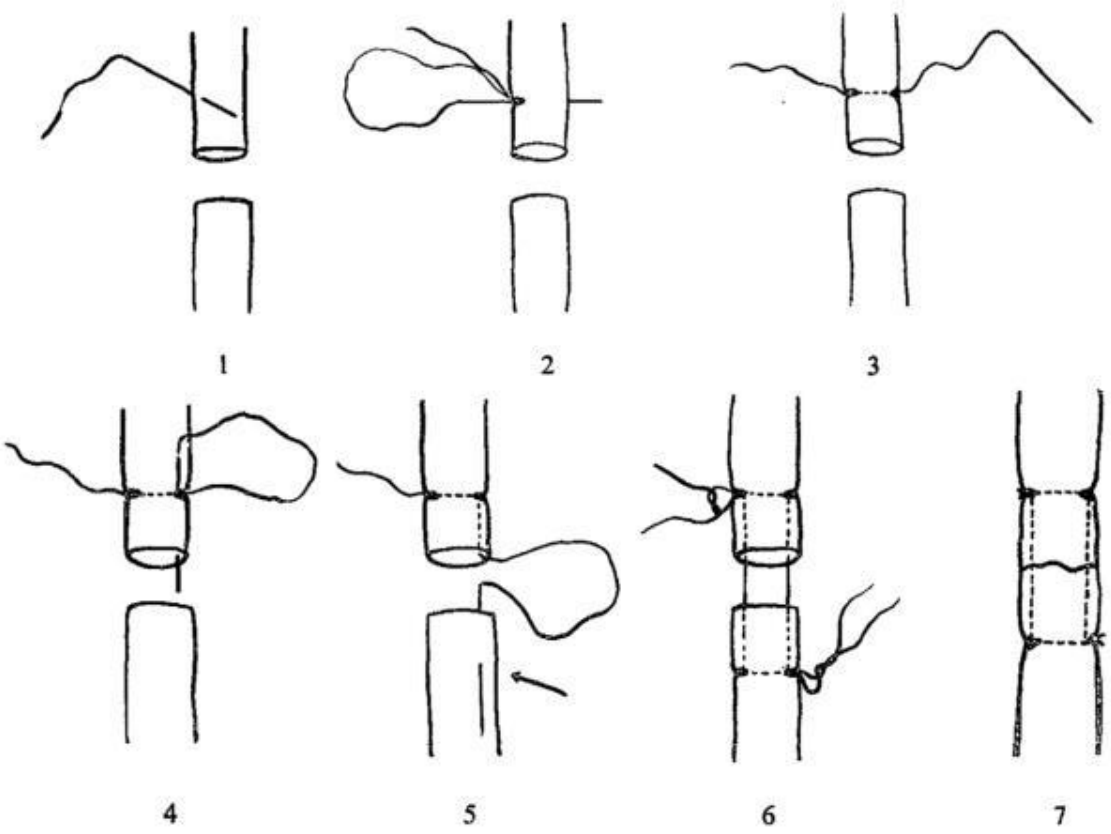


**Fig 1: Kessler's description of the grasping technique of tendon repair.[33] (history and evolution of Kessler's repair)**

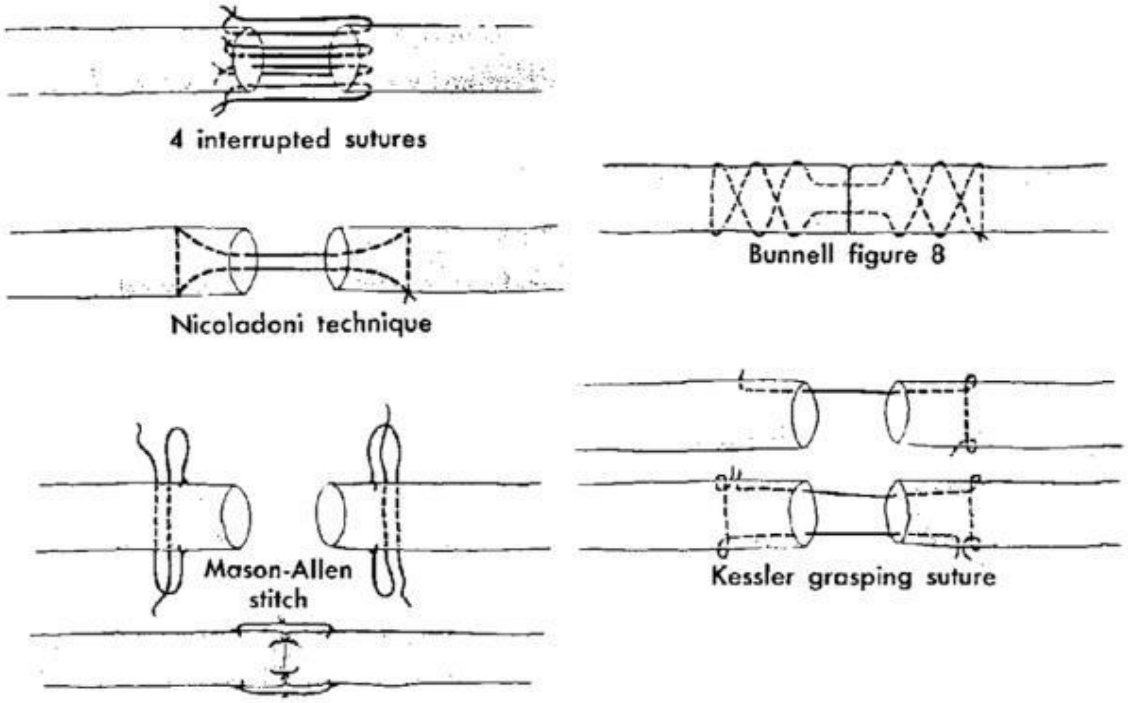


**Fig 2: The 5 techniques of end-to-end tendon repair tested by Urbaniak et al [34]. (AAOS Symposium on Tendon Surgery in the Hand)**

Sabestin et al [35] in their detailed work on the evolution of the Kessler repair method, analysed the various repair techniques and stated clearly that all core tendon suture techniques have 3 components: namely, a longitudinal, a transverse, and a link component. While the longitudinal and transverse components are usually placed within the tendon substance, the link component comes to lie outside the tendon and serves as the junction between a longitudinal and a transverse component or between two longitudinal components.

They further stated that the transverse and/or the link components convert the longitudinal pull of the suture to a transverse compressive force and prevent the longitudinal component from pulling out while the longitudinal component in turn allows placement of the transverse and/or link components away from the divided end of the tendon.

Core tendon repairs can be re-enforced by epitendinous sutures. Mckeon et al [36] have reported that Krackow's technique showed greater mechanical strength compared to Kessler's and Bunnell repair methods, though this has not been validated by other studies.

Where tendon gaps occur after freshening the gaps as is commonly seen in bicycle spoke injuries and in degenerative ruptures, augmentations, allograph tendon transfers or use synthetic materials are the available options [37,38,39]

Available augmentation options include fascial turn down augmentation, mid-section tendon turn down augmentation (turn-o-plasty), and plantaris tendon augmentation.

Peroneus brevis and flexor hallucis tendon transfers are reported as viable options when large gaps up to 5 cm exist [37,38]. The harvested tendons are usually weaved to increase the mechanical strength (Pulvertaft technique) and attached to the calcaneus via anchor stitches [40].

Based on available evidence the properties of available open repair techniques can be compared as shown in table 1.

**Table 1: Comparison of outcomes of various open repair techniques**

| Repair techniques | Restoration of length | Usefulness when length gaps exist | Ease of repair | Minimum Complication rates | Tendon overlength |
|---|---|---|---|---|---|
| Suture repair | +++ | + | +++ | +++ | + |
| Facia augments | ++ | ++ | ++ | ++ | +++ |
| Tendon transfers | ++ | +++ | + | ++ | +++ |
| Synthetic grafts | ++ | +++ | + | + | +++ |
| Tendon augments | ++ | ++ | ++ | ++ | ++ |

**Key: + Fair, ++ Good, +++Excellent**

Post-operatively, the limb is placed in a cast or brace immobilization with the foot in plantar flexion or plantigrade position depending on the repair type and the severity of injury for 1-2 weeks. Ambulation is commenced based on available protocol and guided by outcome from physical therapy.

Other complications like wound dehiscence, sural nerve injury, and limitations in the ankle range of motion have been reported with open techniques [8,41].

**Percutaneous Repairs**

Percutaneous repair methods reduced infection rates drastically and improved patients return to work and sports but the risk of injury to the sural nerve was significantly higher with this method [32]. Increased re-operation rates have also been reported [32] since the repair is regarded as not strong enough compared to the open type.

This option is ideal for ruptures less than 3 weeks, in patients where wound infection concerns are a major issue and for those concerned about a surgical scar associated with open repairs.

Traditionally percutaneous method involves accessing the rupture tendon through 3-6 separate stabs at the medial and lateral side of the tendon to introduce sutures for repair of the tendon. The main drawbacks of this repair method are the lack of adequate exposure for good tendon repair leading to high re-rupture rates and the frequent association with sural nerve injuries.

Web and Bannister [42] proposed a technique that places stab incisions away for the sural nerve and reported fewer nerve injuries compared to the traditional method. The re-ruptures were still significantly higher with their method [42].

More recently the Achillon system as reported by Assal et al [43] and the percutaneous Achilles repair system (PARS) as reported by Hsu et al [32] are novel attempts to reduce the incidence of sural nerve injuries and improve the knot tying for repairs. Both studies report minimal nerve injuries and re-rupture rates but create a significant risk of injury to the paratenon which is vital to the healing of the Achilles tendon.

Endoscopic repair has also been reported as a recent advance in minimally invasive surgical repair of Achilles tendon ruptures [44,45]. This technique involves the insertion of arthroscopic probes though medially paced stab incision to visualize the tendon and perform repairs. Excellent results in terms of early return to physical activities, minimal wound complications and iatrogenic nerve injuries have been reported [45,46].

**Ultrasound-Guided Repairs**

The use of ultrasonography to guide precise localization of tendon rupture and assist in repair has shown promise in minimizing the complication of nerve injuries. Both Lui et al [47] and Wang et al [48,49] have extensively reported the benefits of USS-guided repairs in localizing the tendon rupture, localizing suture placement, allowing better suturing of the tendon, preventing sural nerve injury, and reducing wound complications.

Wang et al [48,49] reported only one nerve injury among 250 patients treated with this method. No re-rupture, no deep wound infection, and no deep vein thrombosis. The drawback with this method is the user-dependency of ultrasonography and the lesser tensile strength of the repairs compared to open methods.

The available treatment modalities are evaluated based on the following outcome measures: Length of hospital stay, Superficial Wound infection, Deep wound infection, Nerve injury, Ankle stiffness, Intervention-ambulation interval, Post-operative pain, Re-intervention rates, Period of cast immobilization, Return to work and sports, Cosmetic appearance of skin and Cost of treatment.

**Table 2: Comparison of outcome measures from the different treatment methods**

| **Outcome measures** | **Conservative treatment** | **Open surgical repair** | **Percutaneous repair** | **USS-guided repairs** |
|---|---|---|---|---|
| Length of hospital stay | + | +++ | + | + |
| Superficial wound infection rate | - | +++ | ++ | ++ |
| Deep wound infection rates | - | +++ | + | - |
| Nerve injury | - | + | +++ | + |
| Ankle stiffness | +++ | ++ | + | + |
| Intervention-ambulation interval | +++ | ++ | + | + |
| Post operative pain | - | ++ | + | + |
| Re-intervention rates | +++ | + | ++ | ++ |
| Period of cast immobilization | +++ | ++ | ++ | + |
| Early return to work and sports | + | ++ | +++ | +++ |
| Cosmetic appearance of the skin | +++ | + | ++ | ++ |
| Low cost of treatment | +++ | + | + | + |

**Key: + Fair ++ Good +++Excellent**

**Physical Rehabilitation**

Recent evidence has shown that accelerated functional rehabilitation can improve outcome of treatment and reduce treatment complications irrespective of treatment modality [50,51]. The replacement of rigid cast immobilization with functional bracing and the early commencement of ambulation have been reported to improve outcome from surgical and non-surgical treatment modalities [52,53].

Physical rehabilitation protocol includes range of motion exercises at the ankle and knee, stretches of the calf muscles, calf muscle strengthening exercises as well as proprioception exercises.

## Conclusion

Achilles tendon injuries are common in orthopedic practice. The knowledge of available treatment options with their strengths and drawbacks will guide the orthopedic surgeon in selecting the best option for each patient. Open surgical techniques remain common and provide the best exposure for a good repair. Conservative treatment is a viable alternative when cost consideration is paramount.

Since the controversy remains as to the best treatment option, appropriate patient selection guided by the severity of the injury, the age of the patient, pre-injury status, work demand for the patient, experience of the surgeon, available equipment and expertise, local soft tissue condition and the patient's preferences are key to successful outcome. Elaborate discussion with patients is vital to having the satisfied post-operative patient.

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