


## Proceeding

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# Achilles tendon pathologies: How to choose the best treatment

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### ABSTRACT

The Achilles tendon is the thickest and strongest tendon of the human body and it gets frequently injured during sports activity. The incidence of Achilles tendon pathologies has increased over the last decades, especially in the last few years, as a result of the increased sports participation among general population and for the diffusion of competitive sports at a high level. Although the increased interest and number of studies about Achilles tendon pathologies, at the moment there is not a consensual point of view on which is the best treatment for Achilles tendon injuries, and its management is still controversial. Treatment options mainly include conservative treatment and surgical repair. The decision for treatment in patients with an Achilles tendon pathology should be tailored on patient's needs and level of activity, since patients with high activity levels may accept the risk of a higher complication rate to rapidly return to previous activity, while less active patients or those who cannot undergo surgery due to comorbidities may choose the non-operative option to decrease the risk of infection and other complications. The aim of this article is to give an insight about the most used and recent treatment options for Achilles tendon pathologies.

**Keywords:** Achilles tendon; Tendinopathy; Tendon injuries; Therapeutics.

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## INTRODUCTION

The Achilles tendon is the thickest, strongest and largest tendon in the human body, and it can undergo both degenerative and traumatic processes (Aicale et al., 2018; Maffulli et al., 2018).

Tendinopathies are one of the most frequent orthopaedic injuries (Loiacono et al., 2019), and the Achilles tendon is the most commonly injured tendon in the human body, accounting for 20% of all tendon ruptures (Oda et al., 2017). Ruptures of the Achilles tendon occur mainly during sports activities, more frequently in middle-aged men, especially untrained and recreational athletes who play sports occasionally (Wertz et al., 2013), even though ruptures can occur in younger people.

The incidence of Achilles tendon ruptures has increased over the last several decades, probably as a result of widespread sports participation (Lantto et al., 2015; Maffulli et al., 1999).

Patients with an Achilles tendon rupture report sudden and severe pain in the acute phase, and, if left untreated, the injury result in worsened physical function (Bertelli et al., 2009).

Achilles tendon tears necessitate a prolonged recovery, leaving a 10% to 30% reduction in functional calf strength (Heikkinen et al., 2016; Olsson et al., 2011; Olsson et al., 2013; Silbernagel et al., 2012; Willits et al., 2010) and endurance (Bostick et al., 2010) despite increased muscle activity (Horstmann et al., 2012; Suydam et al., 2015). The injury produces long-term limitations (Heikkinen et al., 2016; Horstmann et al., 2012; Lantto et al., 2015; Mavrodontidis et al., 2015), and many patients fail to return to sports activities at the same level of performance as before injury (Zellers et al., 2016).

Achilles tendinopathy is clinically characterized by pain and swelling, in and around the tendon, mainly arising from overuse, but often presenting in middle-aged overweight patients with no history of increased physical activity (Maffulli et al., 1998; Sirico et al., 2020; Tarantino and Brancaccio, 2019). It can be categorized as insertional and non-insertional, two distinct disorders with different underlying pathophysiology and management options (Longo et al., 2008). Achilles tendinopathy is a common cause of disability in many athletes because of continuous prolonged intense functional demands imposed on the Achilles tendon, with pain being the main symptom of this pathology, it may occur during the entire exercise session, and it may interfere with activities of daily living (Corrado et al., 2019; Corrado et al., 2020; Corrado et al., 2020; Maffulli et al., 2015).

The diagnosis relies on clinical examination, and imaging techniques can be useful in providing additional clinical information (Maffulli et al., 2020).

After rupture, tendons heal forming scar tissue, and most will never regain the same collagen structure, composition, and organization of healthy tissue (Aicale et al., 2017; Bisaccia et al., 2019). This can lead to a decrease in the mechanical properties of the tissue and increased potential for re-rupture (Lin et al., 2004).

There is no consensus on which is the best treatment for Achilles tendon ruptures, and its management is still controversial. The management of Achilles tendinopathy lacks evidence-based support, and people who suffer from Achilles tendinopathy are at risk of long-term morbidity with unpredictable clinical outcome (Kader et al., 2002).

Treatment options for Achilles tendon rupture include conservative treatment (plaster casting or bracing) and surgical (open or percutaneous) repair (Carmont et al., 2011), while for Achilles tendinopathy treatment options are conservative (such as nonsteroidal anti-inflammatory drugs, eccentric exercises, low-energy shockwave therapy, etc.) treatment (Corrado et al., 2019; Maffulli et al., 2020) and surgical (open or minimally invasive) repair (Aicale et al., 2018). Growing evidences support the use of biological therapies for tendinopathies treatment (Di Meglio et al., 2020).

## ACHILLES TENDON RUPTURE

### ***Management of Achilles tendon rupture: operative or non-operative?***

The management of patients who suffer an Achilles tendon rupture can be broadly divided in 2 groups: operative and non-operative, with the final decision about the treatment usually taken according to the preference of both the surgeon and the patients. The choice of the type of management should take into account the age, occupation, and level of sporting activity of each patient (Longo et al., 2013).

Surgical management consists of open or percutaneous repair, whereas conservative management consists of immobilization or functional bracing (Longo et al., 2013). Recently, more evidence has become available for the use of percutaneous techniques than for open surgery (Khan et al., 2005; Longo et al., 2008), and for the use of early mobilization (Maffulli et al., 2003; Maffulli et al., 2003; Maffulli, 2006). In the last 2 decades, surgical treatment has been the method of choice, especially in athletes and young people and in cases of delayed ruptures, whereas conservative, non-operative management can be used in non-athletes (Farizon et al., 1997).

The goals of the management of Achilles tendon rupture are to minimize the morbidity of the injury, reduce tendon lengthening, optimize rapid return to full function, and minimize other complications (Gross and Nunley, 2016; Longo et al., 2013; Olsson et al., 2013).

Recent systematic reviews have shown that open operative management of acute Achilles tendon ruptures significantly reduces the risk of re-rupture compared with non-operative treatment, but is associated with post-operative wound complications because of the fragility and limited vascularization of the skin (Knobe et al., 2015), and also with an increased risk of infection and morbidity (Saxena et al., 2008).

Deng et al. (Deng et al., 2017) compared the outcomes of surgical treatment versus conservative management for acute Achilles tendon rupture, and pointed out that the total re-rupture rate was significantly lower in surgical group than that in the non-surgical group, but no significant differences were found between the 2 treatment groups in the incidence of deep venous thrombosis, the number who returned to sport, ankle range of motion (dorsiflexion, plantarflexion), Achilles tendon total rupture score, or physical activity scale.

A meta-analysis (van der Eng et al., 2013) showed no significant differences in the rate of re-rupture in surgically treated patients and conservatively treated patients after early weightbearing. An analysis of patients with delayed weightbearing after 4 or more weeks also did not demonstrate a difference in the re-rupture rate. Finally, no differences were seen in the incidence of minor or major complications after early weightbearing in surgically and conservatively treated patients.

Another recent study showed that re-rupture rates in both surgical and non-surgical treatments were low (2.3% and 3.9%, respectively), the rate of postoperative complication after surgery was equally low (4.9%), and the differences between surgical and non-operative management were small for both outcomes (Ochen

et al., 2019). So, even if the differences may have been statistically significant, the clinical relevance was at least questionable (Maffulli and Peretti, 2019).

Manent et al. (Manent et al., 2019) reported no case of total re-rupture and similar efficacy for conservative, percutaneous, and open surgery treatments for acute Achilles tendon rupture at 1-year follow-up with an early weightbearing rehabilitation programme.

Given the above results, what we can state is that even if operative and non-operative treatments have both their pro and cons, there is no general consensus about their efficacy and reliability.

Recent research has focused on how the biomechanical properties of the healing tendon relate to functional performance after treatment, using different treatment methods with the aim of reducing tendon elongation and optimizing stiffness (Schepull et al., 2012; Silbernagel et al., 2010; Silbernagel et al., 2012). In cadaveric studies, Costa et al. (Costa et al., 2006) determined that 1 cm of tenotomised tendon-end separation produced a 12° increase in ankle dorsiflexion. With non-operative management consisting of cast immobilization and early weightbearing, the resting flexion angle has been shown to correlate with muscle strength (Ecker et al., 2016). Minimally invasive repair, using an absorbable suture, and accelerated rehabilitation have been shown to lead to 5° increased dorsiflexion at rest, indicating less tension and/or increased elongation of the muscle-tendon unit.

A recent study by Okoroha et al. (Okoroha et al., 2020) pointed out that no difference was found in tendon lengthening between patients undergoing traditional versus accelerated rehabilitation postoperatively after operative repair of Achilles tendon ruptures. The greatest amount of lengthening was found to occur between 2 and 6 weeks postoperatively, and tendon lengthening decreased significantly after 6 weeks.

### **Conservative management of Achilles tendon rupture**

Conservative treatment consists of immobilization in a below-knee plaster cast in gravity equinus for 4 weeks, followed by a more neutral position for a further 4 weeks: this method is considered the most common non-operative protocol of management of Achilles tendon rupture (Edna, 1980; Gillies and Chalmers, 1970; Jacobs et al., 1978; Lea and Smith, 1972; Lildholdt and Munch-Jorgensen, 1976; Persson and Wredmark, 1979).

Other proposed protocols are to maintain of the gravity equinus position for 2 weeks, followed by a more neutral position for a further 2 weeks. After this period, a below-knee plaster cast with the foot plantigrade is applied for a further 2 weeks, allowing weightbearing for the last 2 weeks of this management regime. After 1 to 3 weeks of immobilization, braces, splints, or shoes with limitation of dorsiflexion and increased heel height have been used for functional rehabilitation (Eames et al., 1997; McComis et al., 1997; Saleh et al., 1992; Thermann et al., 2000).

Following immobilization, the soleus muscle is particularly susceptible to atrophy (Vrbova, 1963). The calf circumference greatly decreases after non-operative management compared with operative management (Häggmark et al., 1986; Heikkinen et al., 2017). The reports on early functional treatment suggest good functional outcome and low re-rupture rates (Wong et al., 2002).

Korkmaz et al. (Korkmaz et al., 2015) recruited patients treated with partial weightbearing beginning the same day of conservative treatment, and other patients treated with non-weightbearing after a 4-week period. Well-conducted early weightbearing treatment regimen for Achilles tendon rupture provides good clinical

outcomes, with a complication rate no higher than after delayed mobilization. Early weightbearing, since it provides advantages such as comfortable healing, reduces lost work time, and allows earlier reintegration into the community.

Conservative management does not present any wound complications and damage to the sural nerve: the high risk of re-rupture (Khan et al., 2004; Möller et al., 2001) of some years ago has generally decreased with the more modern early weightbearing and mobilization techniques (Maffulli and Peretti, 2020).

In 2008, Metz et al. (Metz et al., 2008) pointed out that minimally invasive surgical treatment of acute Achilles tendon rupture appears to have a lower risk of complications than non-operative treatment using functional bracing.

One year later, the same group (Metz et al., 2009) found that, if such complications are avoided, conservative treatment of acute Achilles tendon ruptures by functional bracing is as effective in the recovery of calf muscle strength as minimally invasive surgical repair.

Soroceanu et al. (Soroceanu et al., 2012) suggested that surgical treatment and non-surgical treatment of acute Achilles tendon rupture were equivalent with regard to re-rupture rate when the non-surgical treatment protocol included early range of motion; for this reason, conservative treatment should be considered at centres using functional rehabilitation. Surgical repair should be preferred at centres that do not employ early-range-of-motion protocols as it decreased the re-rupture risk in such patients by 8.8%, with the number of patients needed to treat to prevent one re-rupture being 12.

Costa et al. (Costa et al., 2020) measured the Achilles Tendon Rupture Score, quality of life, complications and resource use of patients receiving non-operative treatment for an Achilles tendon rupture treated with plaster cast compared with those treated with functional bracing. They found that early weightbearing in a functional brace provides similar outcomes to traditional plaster casting and is safe for patients receiving non-operative treatment of Achilles tendon rupture.

Ecker et al. (Ecker et al., 2016) evaluated the use of a standardized non-operative early weightbearing protocol for Achilles tendon rupture consisting in a combination of an equinus cast and rehabilitation boot, which promoted immediate full weightbearing and early functional rehabilitation. They found that their protocol resulted in good functional outcome and patient satisfaction despite observing the common tendon elongation and loss of muscle strength in some patients, with only the 5% of their patients undergone operative treatment due to probably insufficient early tendon healing as seen at 10 to 14 days after the injury. Six weeks of walking-cast in equinus and 6 further weeks of protected walking in the boot gave acceptable protection against re-rupture and excessive tendon lengthening.

### ***Open surgery for Achilles tendon rupture***

Open surgical repair has classically been considered the gold standard for the management of Achilles tendon ruptures in young, fit individuals (Longo et al., 2013). Moreover, the numerous advances in surgical techniques, such as in postoperative rehabilitation protocols, have encouraged many surgeons to favour direct tendon repair (Myerson, 1999). In addition, the excellent results of surgical repair concerning re-rupture rates and calf muscle strength may help many athletes to return to preinjury physical activities (Longo et al., 2013).

There are several open surgical procedures, ranging from a simple end-to-end suturing by Bunnell or Kessler sutures, to more complex repairs using fascial reinforcement or tendon grafts (Soma and Mandelbaum, 1995).

Open end-to-end repair can be carried out under local, regional, or general anaesthesia. The procedure is performed with the patient prone, with the feet over a pillow or outside the operating table. Excessive plantar flexion increases the risk of overtightening the repair and shortening of the tendon (Karlsson et al., 2017). The risk of lengthening is a more common issue and should be avoided (Aicale et al., 2017). Tendon lengthening will lead to reduced plantar flexion strength (Silbernagel et al., 2012). A 5–8 cm posteromedial skin incision is preferred to minimize any risk of injury to the branches of the sural nerve.

Several types of tendon grafts and techniques can be performed to repair an Achilles tendon defect: open reconstruction with gastrocnemius V-Y advancement (Hsu et al., 2017), free/turndown gastrocnemius flap augmentation (Nilsson-Helander et al., 2017), or free hamstring open augmentation for delayed Achilles tendon rupture (Carmont et al., 2017). However, primary augmentation has been shown to produce more complications and no junctional advantages over simple end-to-end repair.

Patients who undergo open operative repair are more often serious athletes who comply well with post-operative management (Longo et al., 2013).

### ***Percutaneous techniques for Achilles tendon rupture***

Percutaneous techniques, comparable for clinical effectiveness to traditional open procedures (Goren et al., 2005), are advocated for their lower complication rates, and provide encouraging results in older individuals, diabetic patients, and high performance athletes (Khan et al., 2005; Maffulli et al., 2010; Maffulli et al., 2011; Maffulli et al., 2011).

The first percutaneous technique was described by Ma & Griffith in 1977: they developed a method for percutaneous repair as a compromise between the open surgical and non-surgical managements (Ma and Griffith, 1977). This technique developed a reputation for iatrogenic sural nerve injuries, although is still commonly used. The Ma & Griffith repair consists of a Bunnell suture applied to the proximal tendon and a box suture distally in the stump inserted through 6 para-tendinous stab incisions.

In 1999, Webb and Bannister developed a percutaneous technique, using 3 midline transverse 2.5-cm incisions over the posterior aspect of the Achilles tendon, rather than performing at the side close to the nerve, which minimized injury to the sural nerve and breakdown of the wound, while maintaining the re-rupture rate of the tendon similar with that achieved by open repair (Webb and Bannister, 1999).

McClelland and Maffulli (McClelland and Maffulli, 2002) later modified this method using stronger absorbable sutures and a Kessler suture configuration.

The Carmont and Maffulli's technique (Carmont and Maffulli, 2008) is cheap, and allows a strong repair, as it enables the use of a greater number of suture strands (eight) for the repair of the Achilles tendon. This technique provided favourable outcome for patients older than 65 and for elite athletes, producing similar outcomes when compared to percutaneous repair in younger patients (Maffulli et al., 2010; Maffulli et al., 2011). This percutaneous technique reduces the risk for sural nerve damage, a troublesome complication in up to 60% of patients following percutaneous repair, and impairing functional outcome (Maes et al., 2006; Majewski et al., 2006). Making longitudinal stab skin incisions parallel to the course of the nerve, as close to

the lateral tendon edge as possible, prevents sural nerve injury (Ma and Griffith, 1977; Majewski et al., 2006). This procedure also allows the torn ends of the tendon to be advanced distally symmetrically, simultaneously pulling the medial and lateral end of the suture, approximating the torn ends until the defect is no longer palpable, maintaining the foot in plantar flexion (Maffulli et al., 2017).

Guillo et al. (Guillo et al., 2013) presented the clinical and functional outcomes of active patients undergoing percutaneous repair (using Carmont and Maffulli's technique) after acute subcutaneous ruptures of the Achilles tendon. This percutaneous technique for repair of the ruptures of the Achilles tendon, associated with immediate protected weightbearing and early active mobilization, provides encouraging outcome in terms of strength and return to pre-operative level of sport activity.

Al-Mouazzen et al. (Al-Mouazzen et al., 2015) found out that percutaneous repair of the Achilles tendon followed by early weightbearing and accelerated rehabilitation achieves good functional outcome.

## **ACHILLES TENDINOPATHY**

### ***Management of Achilles tendinopathy: operative or non-operative?***

The first line of management for Achilles tendinopathy is conservative, and different treatments such as nonsteroidal anti-inflammatory drugs, (NSAIDs) physical therapy, taping, cryotherapy, shock wave therapy, hyperthermia and various peritendinous injections have been used with varying success (Aicale et al., 2018; Aicale et al., 2019; Corrado et al., 2019; Maffulli et al., 2017).

In 24% to 45.5% of patients with Achilles tendinopathy, conservative management is unsuccessful, and surgery is recommended after exhausting conservative management, often tried for at least 6 months, since Achilles tendinopathy may resolve during this period in up to three quarters of patients (Aicale et al., 2018; Maffulli et al., 2020; Maffulli and Kader, 2002; Silbernagel et al., 2011).

However, long-standing Achilles tendinopathy is associated with poor postoperative results, with a greater rate of reoperation before reaching an acceptable outcome (Maffulli et al., 1999).

Surgery is successful in up to 85% of patients (Maffulli and Kader, 2002).

Open surgery for tendinopathy of the main body of the Achilles tendon can be considered if prolonged conservative management fails (Aicale et al., 2018).

The main concern with open surgery is the risk of complications (Aicale et al., 2019). A study on 432 patients reported an overall complication rate of 11% (Paavola et al., 2000). These may include skin edge necrosis, wound infection, seroma formation, haematoma, fibrotic reactions or excessive scar formation, sural nerve irritation or injury, tendon rupture and thromboembolic disease.

For all the above reasons, patients should be informed of the potential failure of the procedure, risks of wound complications and at times prolonged recovery time (Saxena et al., 2008).

The rate of these complications might decrease with the use of minimally invasive techniques (Maffulli et al., 2017).

Minimally invasive techniques reduce the risks of infection, are technically easy to master, and are inexpensive (Aicale et al., 2018). Different minimally invasive procedures can be also used together to optimize the outcomes (Longo et al., 2009).

A systematic review reported that the average success rate of minimally invasive techniques and open procedures is, respectively, 83.6% and 78.9, while the complication rate is, respectively, 5.3% and 10.5% (Lohrer et al., 2016). The success rates of minimally invasive and open treatments are similar, but there is a tendency for more complications to occur in open procedures. Therefore, minimally invasive surgical treatment would appear to be a useful intermediate step between failed conservative treatment and formal open surgery (Aicale et al., 2018; Maffulli et al., 2017).

### **Conservative management of Achilles tendinopathy**

Several conservative therapeutic options are available, but most of them lack hard scientific background (Maffulli and Longo, 2008).

NSAIDs are commonly used for the management of Achilles tendinopathy, even though data showed a modest effect on acute symptoms in the short term (Glaser et al., 2008). The analgesic effect of NSAIDs allows patients to ignore early symptoms, with the risk of further damage to the affected tendon and delaying definitive healing.

NSAIDs can be useful for pain control to allow effective eccentric strengthening (another therapeutic option further described) as well as gastrocnemius and soleus stretching. Potential harms of NSAIDs (such as ulcers, hypertension, etc) need to be weighted up for each patient, balancing potential risks and benefits (Maffulli et al., 2020).

Cryotherapy is also widely used for analgesia, to reduce the metabolic rate of the tendon, and to decrease the extravasation of blood and protein from new capillaries found in tendon injuries (Kannus and Józsa, 1991). Anyway, there is no evidence that this is an effective treatment for Achilles tendinopathy (Maffulli et al., 2020).

Eccentric exercises have been proposed to promote collagen fibres cross-link formation within the tendon, thereby facilitating tendon remodelling (Maffulli and Longo, 2008).

Eccentric exercises are the most effective conservative treatment for non-insertional Achilles tendinopathy (Aicale et al., 2019), with good results reported (Maffulli et al., 2015; Weinreb et al., 2014), and with the Alfredson's protocol being the most commonly used protocol: the exercises are performed in three sets of 15 repetitions, twice a day for 12 weeks (Alfredson et al., 1998).

The results of a meta-analysis, which outlined the best pooled data supporting eccentric exercises, reported that the majority of the studies adopted the Alfredson's protocol (Sussmilch-Leitch et al., 2012). Alfredson and other Scandinavian authors have reported excellent results in prospective randomized control trials (Mafi et al., 2001; Roos et al., 2004; Silbernagel et al., 2001).

The results of eccentric training from other study groups are less convincing, with a 50–60% of good outcome after a regime of eccentric training both in athletic and sedentary patients (Sayana and Maffulli, 2007) or even lower (Rompe et al., 2007; Sayana and Maffulli, 2007); this can result from many factors, and the protocol requires motivated and compliant patients.



Eccentric exercises alone may not work in all patients (Sayana and Maffulli, 2007), and their the mechanism of action is not completely understood (Maffulli et al., 2015).

In general, the overall trend suggests a positive effect of eccentric exercises, with no reported adverse effects (Maffulli and Longo, 2008). Combining eccentric training and shock wave therapy produces higher success rates compared to eccentric loading alone or shock wave therapy alone (Rompe et al., 2009).

Other protocols, such as eccentric–concentric progressing to eccentric (i.e. Silbernagel combined) (Silbernagel et al., 2001) and eccentric–concentric (i.e. Stanish and Curwin) (Stanish et al., 1986), have been described (Aicale et al., 2019). A systematic review showed that combined type exercises have equivalent results to the traditional Alfredson’s protocol (Malliaras et al., 2013). Isotonic, isokinetic and concentric loading have also been described, but are inferior to the eccentric-type exercises (Mafi et al., 2001; Niesen-Vertommen et al., 1992).

Where available, extracorporeal shockwave therapy (ESWT) should probably be a second-line treatment (Aicale et al., 2018; Aicale et al., 2019; Corrado et al. 2019). ESWT works on two aspects of the clinical response, that are tissue healing and pain transmission (Aicale et al., 2019).

The combined use of low-energy shock wave therapy and eccentric exercises is beneficial (Kane et al., 2008). However, when low energy shock wave therapy is not used following the recommendations and modalities outlined in the available trials, the results can be disappointing (Costa et al., 2005).

Orthotics are widely used in conservative management, with heel pads being the most commonly prescribed (Maffulli et al., 2020). There is little evidence to support their use (Lowdon et al., 1984). No differences between management with the AirHeel brace and an eccentric training programme were found in patients with chronic Achilles tendon pain (Petersen et al., 2007). The combination of eccentric training with the AirHeel Brace does not produce a synergistic effect (de Jonge et al., 2010; Knobloch et al., 2008; Knobloch et al., 2008; Petersen et al., 2007).

The efficacy of nitric oxide administration via an adhesive patch in patients with tendinopathy of the main body of the Achilles was evaluated by Paoloni et al. (Paoloni et al., 2004). Topical glyceryltrinitrate was effective in chronic noninsertional Achilles tendinopathy, with treatment benefits continuing for 3 years (Paoloni and Murrell, 2007). However, a more recent study questioned the clinical benefit of topical glyceryltrinitrate patches (Kane et al., 2008).

Hyperthermia can be another option for the management of patients with Achilles tendinopathy, with some studies confirming these potential advantages (Giombini et al., 2002).

Ultrasound therapy is widely available and frequently used (Maffulli et al., 2020). However, some studies have repeatedly concluded that there is insufficient evidence to support a beneficial effect of ultrasound therapy at the current clinical dosages (Warden, 2003). A randomized controlled trial by Chester et al. showed similar outcome between heavy eccentric loading and ultrasound for the management of Achilles tendinopathy in subjects with a relatively sedentary lifestyle, with no adverse effects (Chester et al., 2008).

Various injections therapies have been used for Achilles tendinopathies (Maffulli et al., 2020; van Sterkenburg and van Dijk, 2011). At present, studies which demonstrate the superiority of one injection technique or of one substance over another are few (Maffulli et al., 2020).

The use of PRP seems to be growing exponentially, especially among sports medicine physicians, but the only well-designed RCT published on PRP in Achilles tendinopathy showed no significant difference in pain or activity level between PRP and saline injection at 6, 12 or 24 weeks when combined with an eccentric stretching programme (de Vos et al., 2010).

High volume image guided injections significantly reduce pain and improve function in patients with resistant Achilles tendinopathy (Chan et al., 2008) and seem to be more effective in improving outcomes of chronic Achilles tendinopathy than PRP in the short term (Boesen et al., 2017).

### ***Open surgery for Achilles tendinopathy***

Successful results have been reported with open surgery, which is relatively straightforward, showing varying success rates between 50% and 100% (Kvist and Kvist, 1980; Lohrer et al., 2016; Schepisis and Leach, 1987; Snook, 1972) with removal of intra-tendinous lesions and more than 50% of tendon debrided, and late-presenting lesions showing significantly fewer good to excellent results (Maffulli et al., 1999; Maffulli et al., 2020; Paavola et al., 2000). For non-insertional Achilles tendinopathy, surgery has traditionally involved a large incision and excision of all of the pathological tissue. Occasionally, it may require concomitant transfer of a local tendon to reinforce the weakened Achilles tendon (Longo et al., 2009). The peroneus brevis, the ipsilateral free semitendinosus, and the flexor hallucis longus tendons can be used as tendon grafts (Aicale et al., 2017; Aicale et al., 2017; Maffulli et al., 2017).

### ***Minimally invasive techniques for Achilles tendinopathy***

Minimally invasive therapies which strip the paratenon from the tendon, either directly (Longo et al., 2008) or indirectly with high-volume fluid injection (Chan et al., 2008), have shown good initial results in relieving the symptoms of non-insertional Achilles tendinopathy (Alfredson, 2011; Maffulli et al., 2017).

Multiple percutaneous longitudinal tenotomies, which can be performed under ultrasound guidance, produce good results, with the further advantage of being able to perform the procedure under local anaesthesia in an outpatient setting (Maffulli et al., 1997; Testa et al., 2002). Minimally invasive open debridement with resection of the plantaris tendon has also shown promising results with minimal complications in elite athletes and regular patients with non-insertional Achilles tendinopathy (Alfredson, 2011; Calder et al., 2015; Masci et al., 2015; Pearce et al., 2012; van Sterkenburg et al., 2011).

The endoscopic procedures are useful to minimize the soft tissue dissection and to supplement junction without restoring anatomical continuity (Aicale et al., 2017; Aicale et al., 2017; Aicale et al., 2019; Maffulli et al., 2017; Maffulli et al., 2020).

These techniques may be securely performed, are minimally invasive, have low morbidity, and allow most patients to return to pre-injury sporting and daily activities (Maffulli et al., 2017).

There are no comparative studies between the different minimally invasive approaches, and therefore it is unclear whether it is necessary to perform longitudinal tenotomies or to excise the plantaris tendon (Aicale et al., 2019).

Therefore, minimally invasive surgical treatment would appear to be a useful intermediate step between failed conservative treatment and formal open surgery (Maffulli et al., 2017).

## CONCLUSIONS FOR ACHILLES TENDON RUPTURE

There is no consensus regarding the best treatment of Achilles tendon pathologies, and the literature on the different available treatment options is far from being universally accepted.

In a recent retrospective study, Maffulli et al. (Maffulli et al., 2017) found out that clinical and functional outcomes following surgical repair, percutaneous and open, of the Achilles tendon are significantly improved than following conservative management. They pointed out that percutaneous repair is a good compromise, allowing accurate re-approximation of the tendon ends, and avoiding wound healing complications (Ma and Griffith, 1977).

Karabinas et al. (Karabinas et al., 2014) compared the post-operative clinical and functional results of percutaneous versus open repair of acute Achilles tendon ruptures: clinical and functional results after both open and percutaneous repair of acute Achilles tendon ruptures are similar, but cosmetic appearance is superior in patients who had a percutaneous treatment.

Minimally invasive surgery can produce similar results to those obtained with open surgery, providing decreased peri-operative morbidity, decreased duration of hospital stay, and reduced costs (d'Addona et al., 2020). Multicentre studies with longer follow-up are needed to justify the long-term advantages of these techniques over traditional ones (Maffulli et al., 2010).

Treatment should attempt optimal restoration of tendon length, tension, and stiffness.

Some patients may prefer non-operative treatment with a higher rate of re-rupture and an increased risk of tendon elongation, while other patients may prefer to undergo surgery that may offer superior functional outcomes, at the risk of an increased rate of wound complications.

Although there is no clear consensus regarding the optimal postoperative rehabilitation protocol for this injury, most physicians advocate early range of motion exercises and weightbearing. In the future, tissue engineering may lead to improved management of these injuries (Maquirriain, 2011).

## CONCLUSION FOR ACHILLES TENDINOPATHY

The management of tendinopathy remains a major challenge. Advances in operative management are being made and are underpinned by a greater understanding of the pathologic changes of the overuse tendon injury within sport (Aicale et al., 2018).

The natural history and clinical course of Achilles tendinopathy are unclear, and the condition may be self-limiting in many patients. The lesion is a failed healing response of the tendon, with differences dependent on the site of the lesion (Aicale et al., 2018). Therefore, it is important to establish whether the many commonly used treatments, including surgery, really work (Maffulli et al., 2020).

It would be reasonable to refer the patient to a physical therapist to start a programme of eccentric exercises. If the condition does not respond to these interventions, shock wave therapy, or nitric oxide patches might be considered, although data on their efficacy are limited (Maffulli et al., 2020). The high recurrence rate for Achilles tendinopathy when managed conservatively reflects the chronic and recurrent character of this condition (Aicale et al., 2018). The possibility of surgery should be discussed with the patient after at least

three to 6 months of nonoperative management (Maffulli et al., 2020). Good outcomes have been obtained in refractory cases in Achilles tendinopathy with the use of surgery (Aicale et al., 2018). However, we need for further controlled studies to evaluate and improve more novel treatment approaches (Aicale et al., 2018).

Patients should understand that symptoms may recur with either conservative or surgical approaches. Teaching patients to control the symptoms may be more beneficial than leading them to believe that Achilles tendinopathy is fully curable (Maffulli et al., 2020).

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