Abstract
There is still much controversy in the literature regarding the best treatment for ruptures of the Achilles tendon. After a brief review of the literature regarding the advantages and disadvantages of conservative, open surgery and percutaneous and mini-invasive surgical techniques, we suggest an algorithm treatment for Achilles tendon ruptures. Based on our extensive experience, we believe that the surgical technique should be chosen according to both the type of lesion and the type of patient injured; the factors to be considered are age, rupture-predisposing factors, risk factors, general condition, functional capacity, sport activity level, lesion level and the gap of the lesion. We then consider two different minimally invasive surgical techniques: the percutaneous Ma and Griffith modified technique and the minimally invasive Achillon System technique.

Keywords
Achilles tendon, rupture, percutaneous, mini-invasive technique

Over the past decade the incidence of acute Achilles tendon rupture has increased, reflecting the greater prevalence of people who are involved in sports, with the highest incidence being in men 30–50 years of age.1

Treatment of Achilles tendon ruptures is still debated in the literature; there are numerous publications that widely report the advantages, disadvantages and complications of different types of treatment. Generally, these can be grouped into four categories: conservative treatment (classic or functional), open surgery treatment (with different types of suture, with or without augmentation), percutaneous surgical treatment and mini-invasive surgical treatment (using specialised instruments). However, the majority of publications demonstrate that, to date, there is no consensus in terms of the best treatment.2–5 In particular, the percentage of re-rupture with conservative treatment ranges from 10 to 30%,6–8 but this rate can be reduced if treatment is performed within 48 hours from injury.7,9,10 Good results have been reported with functional conservative treatment followed by ecotomography in subjects in whom the dislocation of the stumps was not above 1cm, the foot was at 90º and the stumps were well-matched when the foot was 20º plantarflexed.11 The rate of re-rupture is clearly reduced (5%) if open surgery is performed.12,13,14 Otherwise, the rate of surgical complications, such as wound dehiscence, infections, sural nerve injuries or cheloid growth, is up to 20%.15,16,17 The rate of surgical wound complications significantly rises to 42.1% if certain risk factors, such as diabetes, smoking or steroid therapy, are present.18

Percutaneous and mini-invasive techniques with or without the use of specific instruments limit the rate of open surgical complications; otherwise, the rate of re-rupture is almost 10% and the onset of other complications such as stump malalignment, protracted healing, skin retraction and nodules or sural nerve entrapments are in the order of 13%.19 Recently, a short-term experience with arthroscopically assisted percutaneous suture – which seems to reduce the rate of complications – has been reported in the literature.20 Nevertheless, considering reports over the last 15 years, we find that good clinical and functional results are probably due more to early functional rehabilitation than to the kind of treatment or the surgical technique adopted.21–26 In fact, it has been demonstrated that this allows better alignment of collagen fibres during healing, improvement of the resistance of scar tissue and reduced recovery time.27 Thus, many different post-operative protocols, more or less aggressive, have been described.

In many cases, these functional or semi-functional protocols are managed with the help of a walker boot. Considering these new experiences, an important suggestion is that the aggressiveness of the post-operative programme should depend on the strength of the suture applied in surgery and on the type of surgical technique to avoid lengthening of the tendon, prolonging healing or early tendon re-ruptures. Undoubtedly, an out-of-date concept is that the knee must be immobilised after surgery to avoid stresses on the suture when the knee is extended; in fact, it has been demonstrated that at 30º tibio–talar plantar flexion – the mechanical traction effect on the restored tendon – is neutralised, even if the knee is fully extended.28

After extensive experience, our orthopaedic school believes that surgical treatment results in better functional outcomes with shorter recovery time, even in the presence of major risks of complications.29,30
Cartilage and Tendon

In cases of percutaneous sutures, the patient, under general spinal or block anaesthesia, is placed in a prone position with the knee flexed at 15°. Both feet are prepared in the surgical field in order to adapt the tension of the suture to the physiological equinus of the uninvolved side. A pneumatic tourniquet is optional. The tendon defect is identified on palpation and three pairs of 5mm skin incisions are made medial and lateral to the tendon edge: one pair at the lesion site, one pair distally at the distal stump site and one pair proximally at the proximal stump site, both in healthy tendinous tissue. To minimise the risk of trapping the sural nerve at the proximal stump, the two skin incisions are made closer together. In fact, the sural nerve crosses the lateral edge of the tendon at about 9.8cm proximally from the calcaneal insertion of the tendon. Using small forceps, the paratenon is opened at each incision level.

The modification of the original Ma and Griffith™ technique consists of two n.2 Bunnel-type bioreabsorbable sutures that are passed on each stump with a large needle beginning transversely from the proximal and distal couples of the incisions. The stitches are then tightened and knotted up to the foot, reaching the same equinus position of the uninvolved foot. The skin incisions are then sutured with 3-0 reabsorbable sutures (see Figures 1 and 2). In cases of minimally invasive sutures, we utilise the technique as reported by Assal. With the patient in the same position and under tourniquet at the thigh level, a longitudinal medial paratendinous incision 2–3cm in length is made at the lesion level. The paratenon is incised and the proximal stump is identified. Pulling the proximal tendon stump with forceps, the Achillon device is introduced under the fascia with the stump that comes between the two internal branches. When the device is introduced, it is gradually widened to follow the progressive proximal enlargement of the tendon. Three n.1 absorbable threads are then passed through the Achillon branches and the tendon with a straight needle. The device is slowly withdrawn and progressively closed. In this way, the three suture threads exit from the incision, trapping the proximal tendon stump inside the fascia. The same manoeuvres are performed in the distal stump. The six threads are knotted with the foot in the same equinus position as the uninvolved side. Suturing of the paratenon and the skin is then performed using 3-0 reabsorbable sutures (see Figure 2).

Using these two latter mini-invasive techniques, a walker boot at 25–30° of plantar flexion is applied directly in the operating room. Soon after surgery, antithromboembolic therapy is initiated and continued until the ninth week. All sutures are removed 15 days after surgery. We then institute the same semi-functional rehabilitation programme. The walker boot is maintained for eight weeks. During the first two weeks, the patient is at rest without weight-bearing. At the beginning of the third week, a partial load up to 15kg is permitted and home cycling with splint is begun. At the beginning of the fourth week, the boot is blocked in a neutral ankle position and active motion without the boot is permitted from 0 to 25º of plantarflexion. At the sixth week, a partial load of up to 25kg is permitted and increased progressively up to full load, associated with active motion with 5º of dorsiflexion. After eight weeks, progressive full load is reached and orthosis is abandoned. A more intensive programme of ankle motion, stretching and isometric and proprioceptive exercises is then progressively instituted.

Recently, these two techniques have been retrospectively compared in two homogeneous groups of patients who showed...
In fact, in recent injuries, functional results of end-to-end sutures overlap with those with augmentation that also have a higher risk of complications due to the increased thickness of the repaired tendon.42 We believe we need an open end-to-end suture without augmentation (see Figure 3).

In open surgery of the broken Achilles tendon, internal para-achillea stump difficult.43

For treatment of re-ruptures or in invertebrate injuries exceeding the range of four weeks from injury, there are numerous techniques44 that may be divided into several distinct groups: end-to-end suture, plastics with autologous tissue (fascia lata, semitendinous, gracilis, patellar tendon), transposition of regional tendons (flexor hallucis longus, flexor digitorum longus, peroneal, plantargractalis, posterior tibial), plastics with reversal of flaps end of gemella muscles, V or Y proximal plastics with pulling of the proximal stump to the bone for example by using small anchors.

In all cases, in order to achieve good results we need to be able to restore tendon continuity using a functionally adequate length of the mio-tendinous unit: an excessive lengthening in fact involves a loss of force in plantar flexion, while a shortening leads to a sometimes disastrous situations.

Post-operative immobilisation, both in tendinitis and in subcutaneous breaks, regardless of the surgical technique used, no longer appears to be the cornerstone of a good result. However, an early resumption of function after the operated tendon is mechanically sealed contributes to the quality of both the clinical and the functional result as much as the surgical act itself.