Chapter 1
Endoscopic Assisted Percutaneous Achilles Tendon Repair

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The Achilles tendon is the strongest tendon in the human body [1]. Hippocrates said "this tendon, if bruised or cut, causes the most acute fevers, induces choking, deranges the mind and at length brings death" [2]. Achilles tendon rupture has been the focus of many studies since Ambroise Paré initially

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described it in 1575 [3]. Achilles tendon ruptures are the third most frequent major tendon ruptures, following rotator cuff and quadriceps ruptures [4, 5]. Nevertheless, there is no consensus on the optimal management, and management is still determined by the preferences of the surgeon and the patient. Cast immobilization may lead to suboptimal healing, with elongation of the tendon, reduced strength of the calf muscles, and an unacceptably high rate of re-rupture [6–10].

Open surgical repair of the Achilles tendon carries specific risks including adhesions between the tendon and the skin, infection, and particularly wound breakdown [11–14]. Although Ma and Griffith introduced the percutaneous repair technique to avoid these complications, percutaneous repair may not achieve satisfactory contact of the tendon stumps and adequate initial fixation [15]. In addition, sural nerve entrapment is a reported complication of this technique [16, 17]. Only recently have safe and sound techniques been developed, and some are described in other chapters of this book by Prof Maffulli.

Percutaneous repair has become popular. The advantages of the operative and conservative methods are combined in minimally invasive percutaneous repair techniques, but these techniques do not allow direct visualization of the tendon ends (Fig. 1.1). This may be overcome by performing the percutaneous repair under endoscopic control [18–27].

1.1 The Technique of Endoscopy Assisted Percutaneous Repair

The operation is performed with the patients in prone position with infiltration of local anesthesia in the area to be operated on. No tourniquet is used, and we do not use antibiotic or antithrombotic prophylaxis. Before starting the procedure, the rupture site is marked (Fig. 1.2). Then, to minimize local bleeding, proximal (about 5 cm) and distal (about 4 cm) to the palpated gap, the skin, subcutaneous tissues, and peritendon are infiltrated with 20–50 mL 0.9 % saline solution with local anesthetic

FIGURE 1.1 Greater dorsiflexion on the ruptured side than on the healthy side

(1 % Citanest® 5 mL+0.5 % Marcain® 5 mL) around the 8 planned stab wounds, 4 medial and 4 lateral to the tendon, distributed evenly proximally and distal to the rupture (Fig. 1.3), These stab wounds are later enlarged with the nick and spread technique, and used for needle entry. Special attention is paid to the area lateral to the Achilles tendon, especially proximally, where the sural nerve lies close to and crosses the Achilles tendon. The patient is prompted to report any paresthesiae or pain in the area of distribution of the sural nerve at any time

FIGURE 1.2 Palpation of the gap between the ruptured tendon ends using an arthroscopic probe

FIGURE 1.3 Local anaesthetic injection to the subcutaneous tissues from the stab incisions

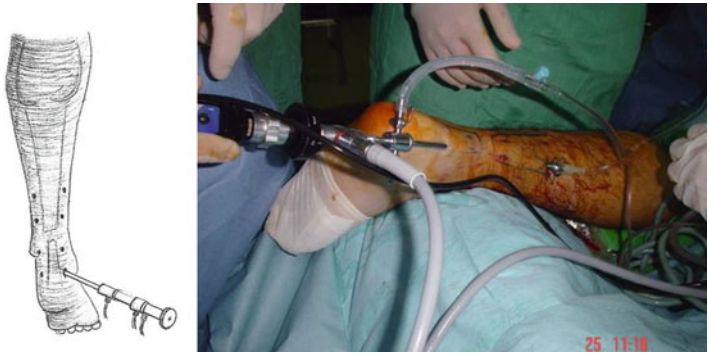

FIGURE 1.4 The placement of the arthroscope from distal medial incision

during the injection of local anaesthetic or during the procedure. If this is experienced, the injection site is moved 0.5–1 cm toward the midline. The injured foot is positioned in approximately 15° of plantar flexion. The tendon and paratenon are examined with a 30º arthroscope (Smith-Nephew, London) via the distal medial incision (Fig. 1.4). After the level of the rupture has been determined, the continuity of the surrounding tissues together with their consistency and vascularization are evaluated. The torn ends of the Achilles tendons are inspected, and, if necessary, are manipulated within the paratenon. The passing of the suture through the Achilles tendon is also controlled with the scope. We use an Ethibond No.5 or PDS No. 5 (Ethicon Inc, Johnson & Johnson, Somerville, NJ) suture with a modified Bunnell configuration.

The needle with the PDS or Ethibond suture is first introduced through the upper medial portal (shown as '1' in Fig. 1.5a). The Achilles tendon is gently palpated between the thumb and the index finger of the opposite hand to make sure that it is caught fully by the needle. This first bite is a transverse one, and the needle emerges from the upper lateral portal (shown as '2' in Fig. 1.5a). The needle is then retrieved, introduced again through it and passed through the upper lateral portal towards portal 3. The procedure is repeated in a proximal to distal direction going from portal 3 to portal 4, from portal 4 to portal 5,

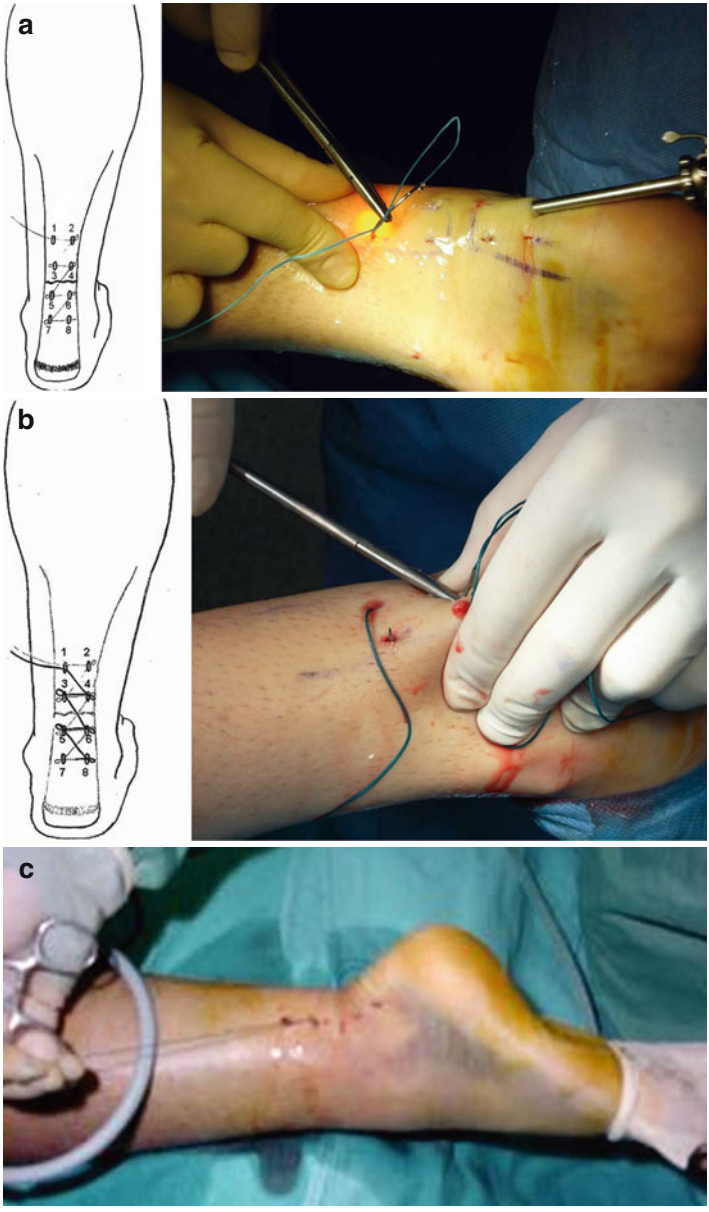

FIGURE 1.5 (**a**, **b**) Schematic diagram of the percutaneous technique (please refer to the text for details). (**c**) The sutures are tied with the ankle in the neutral position

from portal 5 to portal 6, from portal 6 to portal 7, and from portal 7 to portal 8, the distal most lateral portal. At this point, the needle is retrieved from portal 8, introduced through it and passed through the distal most lateral portal towards portal 5, and the procedure described above repeated backward in a distal to proximal direction until the needle is finally returned to the upper medial portal (shown as '1' in Fig. 1.5b).

First, we pass the suture from the proximal medial incision and out from the medial incision just above the ruptured tendon, making sure that the body of the proximal stump of the tendon is squeezed between the thumb and index (Fig. 1.5a). Second, we pass the suture from the same incision and out from the lateral stab incision just above the tendon (Fig. 1.5a). Finally, as in the first step, the suture is passed through this stab incision and out from the distal medial side (Fig. 1.5a).

During suture passage, the arthroscope is placed alternatively in the various entry portals, and the Achilles tendon is inspected from the medial and lateral aspects, and the proximal and distal stumps are inspected from proximal and distal to make sure that the tendon stumps are juxtaposed. Also, through the endoscope we make sure that the sutures are introduced in the tendon at different levels on the coronal plane, so that the chance of them cutting through during the process of tensioning is minimized.

Finally, the sutures are tensioned, and tied in the proximal medial entry portal with the ankle in neutral position whilst checking the tendon approximation through the arthroscope. Before tying the sutures with the ankle in neutral position, the patient is instructed to actively dorsi- and plantar-flex the ankle with the knee at 90° of flexion (Fig. 1.5c) to make sure that appropriate tension is imparted to the suture. A final check is performed, and the suture is knotted fully.

The skin stab incisions are closed with subcutaneous suture and steristrips are used for initial dressing, and a walking brace with the ankle in neutral is applied for at least 3 weeks (Fig. 1.6).

Immediate weight-bearing as tolerated with a walking brace is initiated (for 3 weeks only), alternating with passive range of motion exercises. Physiotherapy includes electrical stimulation of the gastrosoleus complex; cryotherapy and therapeutic ultrasound are applied around the Achilles tendon

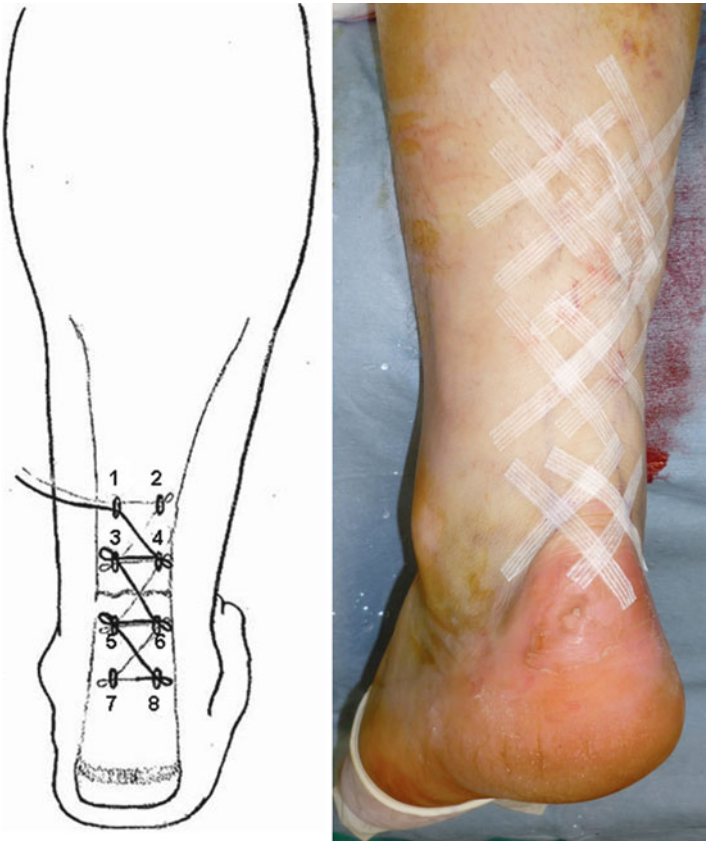

FIGURE 1.6 Final stab wound closure with steristrips

for reduction of edema. Transverse friction massage is used to promote scar and tendon re-formation.

Patients are instructed to move the ankle four times a day between 20º of plantar flexion and 10º of dorsiflexion. The patients complete gentle isometric, eccentric and concentric exercises of the ankle several times a day, with flexion and extension of the toes in a supine position, and full plantar flexion and dorsiflexion of the ankle to neutral in a supine position; extension of the knee in a sitting position; flexion of the knee in a prone

position; and extension of the hip in a prone position within first 3 weeks. The walking brace is discontinued after 3 weeks. From the sixth week to tenth week, rehabilitation progresses to using elastic resistance bands; rotation of the ankles; standing on the toes and heels; ankle stretching exercises to flexion with the help of a rubber band; stretching of the calf muscle by standing with the leg to be stretched straight behind and the other leg bent in front and leaning the body forward, with support from a wall or physiotherapist; stretching exercises for the toes and ankle against manual resistance in a sitting position; balance and proprioception exercises on different surface progress from bilateral to unilateral; controlled squats, lunges, bilateral calf raise (progressing to unilateral), toe raises, controlled slow eccentrics vs. body-weight. After 10 weeks, patients start training jogging/running, jumping and eccentric loading exercises, non-competitive sporting activities, sports-specific exercises, and return to physically demanding sports and/or work.

Rehabilitation process

0–3 weeks:	Range of motion: 20º of plantar flexion and 10º of dorsiflexion
0–6 weeks:	Gentle isometric, eccentric and concentric exercises with flexion and extension of the toes, full plantar flexion and dorsiflexion of the ankle to neutral in a supine position; extension of the knee in a sitting position; flexion of the knee in a prone position; and extension of the hip in a prone position
6–10 weeks:	Resistance exercises, rotation of the ankles; standing on the toes and heels; ankle stretching exercises for calf muscles, the toes and ankle, balance and proprioception exercises on different surface progress from bilateral to unilateral; controlled squats, lunges, bilateral calf raise (progressing to unilateral), toe raises, controlled slow eccentrics vs. body-weight
10–↑ weeks:	Start training jogging/running, jumping and eccentric loading exercises, non-competitive sporting activities, sports-specific exercises, and return to physically demanding sports and/or work

Endoscopy-assisted percutaneous repair allows direct observation of the process of suturing the Achilles tendon. This eliminates some of the disadvantages of the percutaneous repair techniques, especially the evaluation of the juxtaposition of the torn ends [18, 30–32]. Endoscopy-assisted percutaneous repair allows early active ankle mobilization and weight bearing after a short period of cast immobilization and thereby, prevents complications due to the prolonged immobilization such as arthrofibrosis, joint stiffness, calf atrophy, damage to the articular cartilage, and deep vein thrombosis. Buchgraber and Pässler [28] compared the results of immobilization and functional postoperative treatment after percutaneous repair of Achilles tendon rupture and found that functional postoperative rehabilitation with early weight-bearing was associated with significantly less severe calf muscle work by the injured leg than postoperative immobilization. Considering these advantages, endoscopy-assisted percutaneous repair of AT may prevent some of the negative issues associated with open, conservative, or percutaneous techniques. Also, this technique could help to prevent the risk of damage to the sural nerve by allowing its direct visualization. However, we stress that knowledge of the local anatomy is necessary to place the stab wounds in the areas less likely to damage this nerve [29, 33].

In endoscopic repair, the paratenon is protected, providing a biological advantage to the mechanical strength of the repair furnished by the suture material. Also, preservation of the paratenon decreases the gliding resistance of the extrasynovial tendons after repetitive motion *in vitro* [33]. Achilles tendoscopy allows direct observation of the hematoma and the stab wounds, and controlled juxtaposition of the tendon ends without damaging the paratenon [34, 35].

Any technique may result in lengthening of the Achilles tendon, possibly from not having closely approximated the tendon ends. Carmont and Maffulli recommend a mini open technique, with a 1.2–1.5 cm transverse incision at the level of the rupture, to directly observe that appropriate juxtaposition of the ruptured tendon ends had been achieved [36].

FIGURE 1.7 Bilaterally operated patient of AT rupture. *Left side* is operated with percutaneous method and *right side* was operated with open surgery previously. The appearance of the wound is cosmetic with percutaneous method

Direct visualization of the tendon ends by endoscope through the stab incisions allows this without any additional incision.

Obviously, the procedure requires experience in soft tissue endoscopy. Percutaneous repair of the Achilles tendon under endoscopic control results excellent wound appearance (Fig. 1.7), This technique resulted in a cosmetic wound appearance, endurable to early-active mobilization and satisfactory clinical recovery without any severe complication. Furthermore, this procedure protects the paratenon, and should enhance biologic recovery. Direct visualization and

manipulation of the tendon ends also provide stable repair that allows early weight-bearing and ambulation, and we have used in athletic individuals. Percutaneous repair is likely more cost effective than open techniques, and, in some settings, endoscopic control carries no additional costs [37].

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