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Endoscopic surgery of the Achilles tendon

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Abstract The value of endoscopic surgery as a minimally invasive treatment is well recognized and includes less perioperative pain, less scarring, minimal blood loss, and faster recovery. While open surgery on the Achilles tendon is notorious for wound complications, the tendon is situated in a well-formed tunnel allowing surgical procedures to be performed endoscopically. Various endoscopic techniques have been successfully applied to the treatment of non-insertional Achilles tendinopathy, Haglund's syndrome, Achilles tendon rupture, and equinus contracture. Although the evidence is currently limited, results from authors acquainted with the techniques have been encouraging. Both an understanding of surgical anatomy of the hindfoot and familiarity in soft tissue endoscopy are required to achieve successful outcomes while minimizing complications.

Keywords Achilles · Tendinopathy · Endoscopy · Gastrocnemius recession · Achilles tendon rupture · Equinus contracture · Calcaneoplasty · Musculoskeletal · Foot and ankle

Introduction

Endoscopic surgery has been one of the fastest growing surgical treatments in orthopaedics for the last decade [1]. The value of endoscopic surgery as a minimally invasive treatment is well recognized and includes less perioperative pain, less scarring, minimal blood loss, and faster recovery [2]. As orthopaedic surgeons are more familiarized with endoscopy of the ankle joint and less so in the subtalar joint, the use of endoscopy is still limited in other parts of the foot and ankle.

The triceps surae are the most important motor units of the lower leg and are responsible for 90% of the plantar flexor energy in normal gait [3]. An injury to the Achilles tendon is also one of the most common sports injuries and can lead to major disabilities. The lifetime cumulative incidence of Achilles tendinopathy can be up to 52% in elite athletes [4]. Surgeries around the Achilles tendon can lead to catastrophic complications in wound healing, dehiscence, and infection—especially in the open treatment of Achilles tendon rupture [5, 6]. Endoscopy has been successfully applied to the treatment of non-insertional Achilles tendinopathy, Haglund's syndrome, Achilles tendon rupture, and gastrocnemius tendon contracture. With some familiarity with soft tissue endoscopy, the author has found the results of the described conditions rewarding with earlier recovery and minimal complications.

Anatomy

The triceps surae is composed of the soleus and the gastrocnemius muscles, which are innervated by the tibial nerve and vessels. The gastrocnemius muscle-tendon unit crosses knee, ankle, and subtalar joints before inserting on the calcaneus, while the soleus crosses only ankle and subtalar joints. Tendons from the two muscle groups join at the midcalf level, with the gastrocnemius tendon situated posteriorly. The conjoined tendon then rotates approximately 90° so that the portion from the soleus inserts

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anteromedially on the calcaneal tuberosity while the portion from the gastrocnemius inserts more posterolaterally [7]. A water shed zone is the region 2-6 cm proximal to the insertion where the Achilles tendon has limited blood supply, making it prone to injury [8, 9]. The Achilles tendon is contained within a well-formed tunnel lined with visceral and parietal paratenon layers [10]. Anteromedially, the plantaris tendon joins the Achilles tendon and stays within the same fibrous tunnel until it inserts on the calcaneal tuberosity in various patterns. The Achilles tendon inserts on the calcaneus at approximately 13 mm (range, 9–22 mm) below the most proximal aspect of the calcaneus tuberosity [11]. Just before it inserts, the tendon is separated from the calcaneus by a horse-shoe shape retrocalcaneal bursa and a Kager's fat pad [12, 13]. Along the posterior aspect of the gastrocnemius muscles and Achilles tendon lies a sural nerve that emerges from the tibial nerve between the two heads of gastrocnemius and is joined by the sural communicating branch of the common peroneal nerve. The nerve travels distally and laterally in the subcutaneous plane towards the lateral heel and lateral border of the foot.

Biomechanics

The Achilles tendon is the strongest tendon in human body, sustaining up to 12.5 times of body weight in certain running activities [14]. The maximum tension on the tendon occurs in the late stance phase. During gait, the plantar flexors produce four times more energy than the dorsiflexors. The triceps surae accounts for approximately 90% of the energy in plantarflexion [3]. The ultimate tensile stress is approximately 100 MPa, with the tendon strain at failure of 4–10% [15]. The viscoelastic property of the tendon allows storage of energy in the stretch-recoil cycle while losing approximately 10% as heat [16–20]. Normally, the gastrocnemius tendon limits the degree of ankle dorsiflexion when the knee is in extension, whereas the entire triceps surae is accounted for when the knee is flexed [21]. Flexibility of the gastrocnemius muscle-tendon unit is essential in order to allow the required ankle dorsiflexion of 10° in late stance phase [22].

Equinus contracture

Equinus contracture is a leading cause of disabilities as well as other secondary pathologies in the foot and ankle [21]. This deformity can lead to an increase in peak plantar pressure as well as the development of plantar foot ulcers, especially in diabetics [23]. Patients with equinus contracture can have difficulties in ambulation due to the interference with heel-to-toe mechanism in stance phase. Patients may modify their walking gait into a more externally-rotated position to facilitate rolling over the forefoot. Equinus contracture of the ankle can lead to several conditions of the forefoot and midfoot, including diabetic forefoot ulcer, metatarsalgia, Morton's neuroma, flatfoot deformity, and plantar fasciitis [24]. A study by Maskill et al. demonstrated a high success rate of 93% for patients with isolated foot pain without structural abnormality by an open gastrocnemius tendon recession [25•]. Prospective randomized studies by Mueller et al. have shown a significant decrease in two-year recurrence of diabetic foot ulcers after an Achilles tendon lengthening to 38% compared with 81% in total contact casting alone [26]. Laborde reported ulcer recurrence of only 16% at an average follow-up of 45 months after gastrocnemius-soleus recession combined with peroneus longus or tibialis posterior tendon release [27]. The accepted criterion for isolated gastrocnemius contracture is ≤5° of maximal ankle dorsiflexion with the knee in full extension, while the combined gastrocnemius and soleus contracture is defined as ≤10° of maximal dorsiflexion with the knee in 90° of flexion [21]. Radiographic examination is also crucial to reveal the presence of intrinsic ankle joint stiffness due to arthritis or bony impingement. A trial of at least six months of non-surgical treatments for the stretching of the Achilles tendon is required prior to a surgical intervention. Endoscopic release of the gastrocnemius was first introduced in 2002 by Saxena [28]. It has been effectively utilized to improve ankle dorsiflexion in pediatric, adult, and diabetic patients [29–33].

Indications

- Protracted Forefoot/midfoot pain with 0° or less of ankle dorsiflexion when the knee is in full extension.
- Diabetic forefoot ulcer with 5° or less of ankle dorsiflexion when the knee is in full extension.

Technique

The patient is placed supine on the operating table. A thigh tourniquet is placed and inflated. A medial portal is established at approximately 1-inch distal the most distal aspect of the medial head of gastrocnemius muscle. A slotted cannula (ECTRA II, Smith & Nephew; Andover, MA) is then inserted in the plane just posterior to the gastrocnemius tendon but anterior to the deep fascia. The ankle is ranged to dorsiflexion to assist in identifying of the medial border of the tendon. The cannula is then passed toward the lateral aspect of the calf. The lateral portal is established inside-out.

Using dry arthroscopic technique, a 4 mm scope is inserted from the medial portal, and a probe is inserted from the lateral portal. Thorough examination of the posterior aspect of the gastrocnemius is performed with the probe to ensure that the sural nerve is not in the plane anterior to the cannula. The nerve can usually be palpated posterior to the cannula subcutaneously. A retrograde knife is then inserted from the lateral portal. The gastrocnemius tendon and underlying soleus fascia is released from medial to lateral with the ankle held in dorsiflexion by the surgeon's chest (Fig. 1). The most medial portion of the gastrocnemius tendon often needs an additional release with the retrograde knife as it curves anteriorly. After a complete release, the ankle should be able to dorsiflex to at least 10°.

The patient can start range of motion and weight bearing exercises in a boot as tolerated immediately. The boot can be weaned off at 4–6 weeks.

Results

Several studies reported the overall satisfactory results of endoscopic release of the gastrocnemius tendon [28, 30–38]. Tashjian investigated the technique and found that incomplete release could occur due to the anatomy of a tendon that has both edges curved anteriorly [39]. The author recommended the use of a stiffer retrograde knife and mini-open incisions on both sides of the tendon for the identification and control of tendon borders. Other endoscopic techniques have been described with the use of either one or two portals with satisfactory outcomes [29–33]. On average, the equinus contracture could be corrected by 12–18° towards dorsiflexion. While the overall complication rate was low, symptoms from sural nerve dysesthesia were described in 0-15% of respondents, a figure arguably greater than the rate of sural nerve injury reported from open gastrocnemius tendon release, which ranged from 0–5% [25•, 40, 41]. The nerve can be injured either directly or from traction caused by tendon lengthening [29].

Fig. 1 Endoscopic gastrocnemius tendon release is performed on left lower extremity. The camera is in the medial portal and the retrograde knife in lateral portal. The surgeon's chest is used apply dorsiflexion force allowing the tendon to be cut under tension

The weakness of the ankle plantarflexion after gastrocnemius tendon release was found to be temporary. Sammarco et al. reported weakness as a complication of an isolated open gastrocnemius recession in one out of forty patients [41]. On average, the strength test of plantarflexion peak torque using a Cybex device improved from 62.6% at six months to 82.2% at 18 months when compared to the non-operative side. Saxena reported that the ability to do a single-leg heel raise returned at approximately 13 weeks postoperatively after an endoscopic gastrocnemius tendon release [30]. This finding is in agreement with a series by Chimera et al. that found superior isokinetic strength at three months postoperatively when compared to preoperative status [42].

Non-insertional Achilles tendinopathy

Achilles tendinopathy is a very common condition that affects runners and other athletes both acutely and chronically. It was found in 1.85 per 1000 Dutch patients registered in primary care and in 2.35 per 1000 of an adult population where the age ranged from 21–60 years [43]. Sports participation was associated in 35% of the cases. While the cause of this condition is still not fully understood, failed healing response has been proposed as the current pathogenesis [44]. Other contributing intrinsic factors include tendon vascularity, hyperthermia, gastrocnemius-soleus dysfunction, age, gender, body weight and height, pes cavus deformity, and lateral ankle instability. Extrinsic factors such as training pattern, poor technique, previous injury, footwear, and training surfaces may also predispose athletes to this condition [45]. MRI can be helpful for questionable cases and for preoperative identification of the diseased portion of the tendon. Several RCTs (Level I) demonstrated promising results of eccentric stretching exercise in the treatment of Achilles non-insertional tendinopathy with the mean pain reduction of 60% [46]. Other adjunctive treatments include the use of ultrasound, night splints, and heel lifts. Although controversial, extracorporeal shock wave therapy and injection therapy with polidocanol were found helpful [47]. Non-surgical treatment should be followed diligently for at least six months prior to a surgical intervention. Standard open surgeries involving tendon debridement were associated with wound complications, scarring, prolonged recovery, and unpredictable results [48]. Minimally invasive surgical approaches were described as alternatives to open procedures, the goals of said approaches being the denervation of the diseased tendon, lysis of tendon adhesion, and stimulation of healing response. Endoscopic treatment has been successfully applied to treat Achilles tendinopathy with or without longitudinal tenotomies [49–51].

Indication

- Non-insertional Achilles tendinopathy with failure of appropriate non-surgical treatment

Technique

Endoscopic debridement is performed using the technique in prone position as described by van Dijk [49]. A 2.7 or 4.0 mm arthroscope is used together with fluid and a pump. The arthroscopic trocar is inserted from a portal created just distal and lateral to the tendon enlargement. The trocar can be used to release the adhesion in the paratenon space by passing it around the tendon. An additional portal is created proximal and medial to the tendon enlargement for a 3.5 mm full-radius shaver, and the scope and the shaver can be interchanged through both portals to allow complete debridement. Under direct visualization, any fibrotic tissue binding between the tendon sheath and the tendon is debrided.

Percutaneous longitudinal tenotomy is performed using a number 11 blade as described by Maffulli [50]. The first tenotomy is from a stab incision on the posterior aspect of the tendon enlargement. The ankle is ranged into dorsiflexion and plantarflexion to assist with the cut. Four more longitudinal tenotomies are made around the first one creating a pattern similar to "number 5" on a dice.

The patient can start range of motion and weight bearing exercises in a boot as tolerated immediately. The boot can be weaned off at 4–6 weeks.

Results

Maffuli reported 71% good-excellent results in 52 runners with non-insertional tendinopathy treated with percutaneous longitudinal tenotomies [43]. Van Dijk et al. successfully treated 20 patients with non-insertional tendinopathy using endoscopic debridement of the diseased portion of the paratenon tissue without complications [40]. The FAOS and SF-36 scores at the mean of six years were comparable to a cohort of people without Achilles tendon complaints. Marquirriain described endoscopic debridement of the peritendinous tissue together with longitudinal tenotomies when a tendinopathy was associated [42]. Excellent results were achieved in six of the seven patients. Pre and post-operative MRI demonstrated normalization of the hyper-intense signal at the diseased portion of the tendon in three patients.

Achilles tendon rupture

Achilles tendon rupture is one of the most critical injuries to the lower extremity, especially for high-demand individuals. Thirty-two percent of NFL players could not return to play in the same league after such an injury [52]. The treatment of Achilles tendon rupture is controversial and is still evolving. According to the recent AAOS guidelines involving extensive review of the literature, only weak recommendations could be made regarding the selection of surgical or nonsurgical treatment [53•]. While the surgical treatment was found to have a smaller rerupture rate, high wound complications were also present [54•]. This development led to the use of a mini-incision with a jig for needle passage and other entirely percutaneous techniques [55, 56]. The use of endoscopy was described as an adjunct to the percutaneous repair and allows an evaluation of the tendon quality, debridement and mobilization of tendon ends, accurate passage of needles, and guided approximation of the tendon ends [57–62].

Indication

- Acute mid-substance Achilles tendon ruptures within 10 days of injury.

Technique

A modified Ma-Griffith technique as described by Halasi is used to create a four-strand construct [58]. The patient is placed in prone position with the tourniquet at the upper thigh. Both legs are prepped and draped to allow comparison of resting tension of the Achilles tendons. The tendon gap is outlined with a marking pen. Six portals are utilized —one on each side of the tendon at the proximal, distal, and at the level of the tear. An arthroscopic cannula with low fluid pressure is inserted from the medial-distal portal into the tendon gap. The tear is evaluated as the tendon sheath is inflated by the fluid pressure. A number 2 Vicryl suture is passed into the tendon using a 3-inch Keith needle. A drill guide is used to avoid sural nerve injury at the lateral-proximal portal. After the construct with two suture loops is completed, both sutures are tied with the ankle held in full equinus. The ankle should be gently ranged during the tying to eliminate laxity in the suture construct. At the end, the resting position of the operated ankle should be slightly more equinus than the contralateral side.

The patient is immobilized in a splint in equinus for three weeks. Progressive weight bearing is then allowed in a boot with a heel lift, which is decreased weekly until the patient can return to normal shoes at eight weeks postoperatively.

Results

Turgut investigated the use of endoscopically assisted Achilles repairs using a Ma-Griffith construct in 16 specimens and reported success in a series of 11 patients without complications [57]. The average return to daily activities was 10–11 weeks. Halasi reported comparable satisfactory results in strength, return to sports, and subjective symptoms for both the percutaneous repair group and the endoscopically assisted repair group [58]. The lower rerupture rate in the endoscopic group was attributed to the ability to control the adaptation of tendon ends. Tang et al. reported all good-excellent Lindholm scores without a complication in 20 patients using endoscopically assist repair with a Kessler technique [60]. Doral performed an endoscopically assisted modified Bunnel repair in 62 patients with 100% satisfactory results and a mean AOFAS score of 94.6 [62]. Ninety-five percent of patients returned to their previous sportive activities. Two patients experienced transient hypoesthesia of the sural nerve that was resolved by six months.

Haglund's syndrome

Haglund's syndrome, or "Pump bump," first appeared in a 1928 single case report and describes a painfully enlarged posterosuperior border of the os calcis associated with wearing of shoes with a rigid heel counter [63]. Clinically, the enlarged posterosuperior aspect of the os calcis is often associated with Achilles insertional tendinopathy, retrocalcaneal bursitis, and superficial adventitious Achilles tendon bursitis [64]. Patients should be initially treated with an eccentric stretching program, night splinting, and orthotics to prevent shoe irritation. Originally, the surgical treatment for this condition involved debridement of the posterosuperior calcaneal spur or a calcaneal wedge osteotomy [65–70]. Complications from the open procedures included soft tissue breakdown, Achilles tendon avulsion, recurrent pain, scar tenderness, altered heel sensation, and stiffness. Van Dijk reported the first series of endoscopic calcaneoplasty in 2001 through medial and lateral portals in prone position [71]. This technique has been used successfully for the treatment of select cases, and pathologies are limited to the retrocalcaneal bursitis and the posterosuperior border of the os calcis as the associated posterior calcaneal step spur are not accessible through the endoscope [64, 72, 73]. On physical examination, the ideal patient will demonstrate tenderness with mediolateral palpation just anterior to the Achilles tendon insertion without direct tenderness on the posterior heel. A lateral radiograph of the hindfoot is essential to evaluate the characteristics of posterosuperior calcaneal border, the presence of calcaneal step spur, and the obliteration of the Kager's triangle due to the presence of retrocalcaneal bursitis [74].

Indication

- Recalcitrant retrocalcaneal bursitis with enlarged posterosuperior border of the os calcis without pain at the Achilles insertion.

Technique

The patient is placed in prone position with a thigh tourniquet. Medial and lateral portals are established at the superior border of the calcaneal tuberosity on both sides of the Achilles insertion. Blunt dissection with hemostats is performed through both portals into the retrocalcaneal bursa. A thorough synovectomy is performed with a 4 mm shaver under direct visualization. The bony prominence is removed with a 4 mm barrel burr, and it is important not to leave any sharp bony prominence on either side of the bone. The adequacy of the excision is confirmed by the absence of impingement with the ankle in full dorsiflexion. Optionally, the amount of bone excision can be guided by lateral fluoroscopy images.

The patient can start both weight bearing and ankle range of motion exercises as tolerated. Normal activities can be resumed at 4–6 weeks.

Results

Scholten and van Dijk reported their results in 36 patients with an average follow-up of 4.5 years [73]. The Ogilvie-Harris score was excellent for 24, good for 6, fair for 4, and poor for 2 patients. The post-operative complications were one case of a heel pad hypoesthesia and one delayed wound healing. On average, the patients returned to work at 5 weeks and to sports at 11 weeks. Jerosch et al. reported the results in 164 patients with an average follow-up of four years [72, 75]. The Ogilvie-Harris score was excellent for 84, good for 71, fair for 5, and poor in 4 patients. Three patients with poor results had ossification at the Achilles insertion. Complications were minor. The authors changed their approach from prone to supine after the first 10 cases due to the easier handling of the foot and better endoscopic exposure.

Future directions

With the steep advancement in surgical and arthroscopic instruments, minimally invasive treatment of the foot and ankle is expected to develop into broader indications while requiring simpler techniques. The use of biologic interventions such as PRP, growth factors, and stem cells may be applicable as an adjuvant to the endoscopic treatment. While the use of endoscopy appeared to be rewarding in experienced hands, more evidence is required to advocate these techniques to general orthopaedic surgeons.

Conclusions

The Achilles tendon is located in a well-formed tunnel, making it technically accessible through endoscopy. Minimally invasive treatment of the Achilles tendon is potentially beneficial because it causes less pain and scarring while allowing a faster recovery time. An understanding of the surgical anatomy of the hindfoot along with a familiarity in soft tissue endoscopy are required to achieve successful outcomes while minimizing complications.

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