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Surgical Correction of Soft-Tissue Ankle Equinus Contracture

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Soft-tissue ankle equinus contracture is a limitation of dorsiflexion motion at the ankle joint and has been identified as a contributing factor in neuropathic ulceration and multiple foot deformities ranging from hallux valgus to Charcot neuro-osteoarthropathy [1–8]. Despite numerous publications on the equinus deformity, there remains disagreement as to what constitutes limited dorsiflexion at the ankle joint. With the knee extended, the reported normal range of ankle joint dorsiflexion in the literature varies from 3° to 15° [9–13], and with the knee flexed to 90°, the normal range has been reported from 10° to 20° or greater [10–12].

The Silfverskiold test (Fig. 1) has been used to differentiate between an isolated gastrocnemius equinus and a gastrocnemius–soleus equinus. Flexion of the knee will increase ankle joint range of motion in the case of an isolated gastrocnemius equinus, as it creates laxity in the gastrocnemius muscle, which originates from the posterior aspect of the femoral condyles, thereby crossing both the knee and the ankle joints [13]. When considering surgical correction of equinus, determination of whether to perform an open gastrocnemius recession (OGR) or endoscopic gastrocnemius recession (EGR), which only addresses the gastrocnemius muscle, or an Achilles tendon lengthening, which lengthens the combined tendon of the gastrocnemius and soleus muscles, traditionally has been based on the Silfverskiold test [1,14], assuming an osseous talotibial exostosis has

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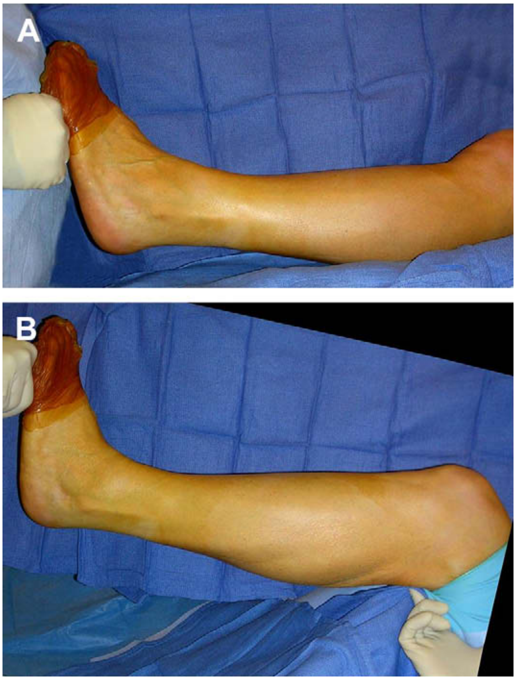


Fig. 1. Demonstration of the Silfverskiold test. With the knee extended, the rear foot is locked in varus, while the foot is dorsiflexed on the leg and the angle between the glabrous junction (where the dorsal and plantar skin meet) at the lateral foot and the longitudinal bisection of the fibula are measured (*A*). With the knee flexed at 90°, the foot is positioned as in *A* and dorsiflexed on the leg with the range of motion again measured in an identical manner (*B*). If ankle joint dorsiflexion increases to normal range with the knee flexed, an isolated gastrocnemius equinus is present. If ankle joint dorsiflexion is decreased with both the knee flexed and extended, a gastrocnemius-soleus equinus is present.

been ruled out by radiographic evaluation. If one considers the timing of passive ankle joint dorsiflexion in the gait cycle, this test is flawed somewhat, as the knee is relatively extended until the heel comes off the ground during toe off. Aronow and colleagues [15] performed a mechanical loading study using 10 fresh frozen cadaveric legs that were loaded with 79 lbs of plantar force through the isolated gastrocnemius, isolated soleus, or combined gastrocnemius–soleus muscles and found similar redistribution of plantar force from the rear foot to the midfoot and forefoot in each of the three muscle sets tested. These findings suggest that there is no clinically significant difference between an isolated gastrocnemius equinus and a gastrocnemius–soleus equinus, which would render the findings of the Silfverskiold test irrelevant in procedure selection. There are, however, several other reasons why one procedure would be preferable to another for an individual patient (Table 1).

Table 1
Procedure selection criteria for equinus correction

Indications for percutaneous tendo-Achilles lengthening	Indications for open gastrocnemius recession	Indications for endoscopic gastrocnemius recession
Spastic equinus	Nonspastic equinus	Nonspastic equinus
Severe deformity	Athlete requiring propulsive strength	No peripheral arterial disease
Peripheral arterial disease	No peripheral arterial disease	Athlete requiring propulsive strength
Status post peripheral bypass surgery	Varicosities absent	Inability to remain nonweight bearing
Varicosities present	Inability to remain nonweight bearing	Previous Achilles tendon surgery
Capable of postoperative nonweight bearing	Previous Achilles tendon surgery	Cosmesis

Percutaneous tendo–Achilles lengthening

Percutaneous tendo–Achilles lengthening (PTAL) is preferred in patients who have peripheral arterial disease or peripheral arterial bypass surgery because of the minimum length of the incisions required to properly complete the procedure with a low risk of primary wound healing complications [6]. Additionally, a greater degree of equinus correction can be obtained with a PTAL than an OGR or EGR, making it ideal for correcting severe equinus deformity [12,16]. Use of the PTAL procedure is necessary in conjunction with partial foot amputations at or proximal to the level of Lisfranc's joint to weaken the posterior calf musculature adequately to prevent excessive pressure on the significantly shortened foot. The patient must be able to remain nonweight bearing for 4 to 6 weeks after a PTAL procedure to limit the potential for overlengthening as a result of partial or complete rupture postoperatively [17,18]. Limited early weight bearing in a robust short-leg cast is allowed for some patients with spastic equinus contracture associated with neuromuscular disease [19,20], as these patients may benefit from slightly more length than was achieved on the operating table. Overlengthening can result in a calcaneal gait and a plantar central heel ulcer that is difficult or impossible to remedy (Fig. 2) [6,18,21–23]. There is also a risk of damage to the tibial nerve medially, the flexor hallucis longus tendon anterior–medially, and the sural nerve laterally with poor surgical technique [6,17]. Patients who have intratendinous Achilles tendon pathology are not good candidates for PTAL because of the increased risk of rupture inherent to incisions through hypovascular tendon [24,25]. The procedure additionally results in a loss of muscle mass that is cosmetically unappealing and functionally disruptive.

Open gastrocnemius recession

OGR is indicated for patients who require maintenance of the strength of the soleus muscle [8,10]. This includes athletes requiring greater propulsive strength to participate in their sport and may include patients with neurologic

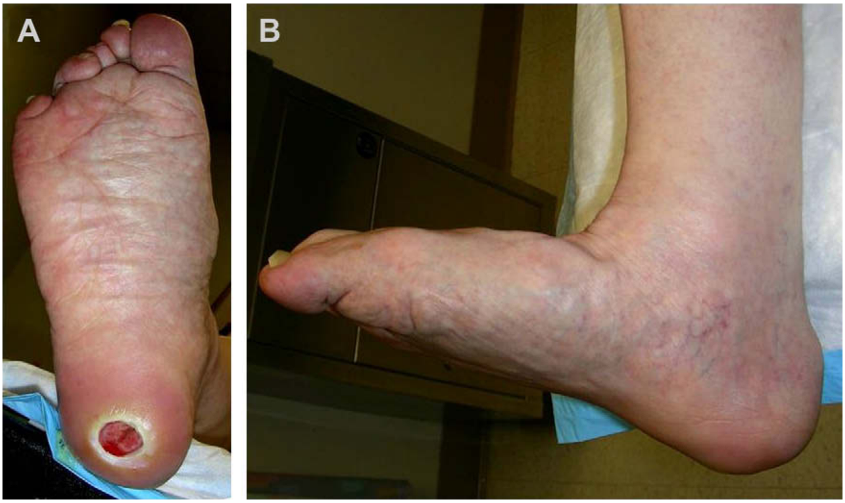


Fig. 2. Plantar central heel ulcer (*A*) in a neuropathic diabetic patient after rupture of the Achilles tendon status after percutaneous tendo-Achilles lengthening (*B*).

conditions causing postural instability, such as cerebral palsy (CP) [26,27] to avoid postoperative crouch during stance. Some authors refute this, finding similar results between PTAL and OGR in patients who have CP [20,28,29]. OGR, when performed in isolation, allows for immediate postoperative weight bearing in a protective walking boot or cast and is therefore a good choice for patients who might have difficulty remaining nonweight bearing. Additionally, there is a lower risk of overlengthening or rupture with this procedure when compared with the PTAL, unless the deep soleal fibers are released, and the aponeurosis is elevated off of the underlying musculature aggressively [6]. Tennis leg is another potential complication of the procedure resulting from dissection of the medial head of the gastrocnemius muscle off of the gastrocnemius aponeurosis, which can result in functional weakness and muscle atrophy. Injury to the lesser saphenous vein or sural nerve is a potential complication of OGR [10,30], particularly with a direct posterior approach. Patients who have varicosities also may have an increased risk of hematoma formation, because dilated, friable veins may be harder to avoid and hemostasis difficult to achieve. In patients who are morbidly obese, determining the appropriate tissue planes may be challenging, resulting in a greater likelihood of neurovascular injury and requiring a larger incision to properly visualize relevant anatomy. This increases the risk of necrosis of the adipose tissue with a resultant higher incidence of wound-healing complications.

Endoscopic gastrocnemius recession

EGR has similar indications to OGR but may be preferred in some instances, because it requires a smaller incision, resulting in a more cosmetic appearance postoperatively [10]. Additionally, the procedure may be less traumatic with a lower likelihood of hematoma formation. Use of the endoscope allows direct visualization and, therefore, protection of the sural nerve and lesser saphenous vein. The entire gastrocnemius aponeurosis also can be seen, ensuring complete transection during the procedure [10]. A thigh or sterile high calf tourniquet is required to ensure a bloodless field, which prevents the endoscope from becoming obscured. The use of a tourniquet is contraindicated in patients who have a history of peripheral arterial disease or peripheral arterial bypass surgery and is not well tolerated by the patient without the use of spinal or general anesthetic. EGR has the same potential complications as OGR.

Surgical techniques

Multiple publications regarding the surgical techniques for PTAL, OGR, and EGR exist, with varying recommendations regarding incision placement and the amount of dorsiflexion that should be achieved intraoperatively. The following techniques include the pearls provided to the author during postgraduate fellowship training (Thomas S. Roukis, DPM, FACFAS, personal communication, 2006) to aid in performance of these procedures and avoid complications associated with them.

Percutaneous tendo–Achilles lengthening

The PTAL is performed with the patient supine. The drape should be placed above the knee to facilitate application of a splint or cast postoperatively. The foot can be positioned on the surgeon's chest and dorsiflexed to apply tension to the Achilles tendon. Alternatively, an assistant can flex the knee, externally rotate the hip, and dorsiflex the foot to allow visualization of the Achilles tendon by the surgeon.

Multiple anatomic considerations have led to the use of incisions placed at 2 cm, 5 cm, and 8 cm proximal to the Achilles tendon insertion as the authors' preferred method of performing the PTAL (Fig. 3). The watershed area of the Achilles tendon is from 2 to 6 cm proximal to its insertion and is an area of relative avascularity that is highly susceptible to rupture [31,32]. Incisions are placed at the extremes of the watershed area to promote healing and 3 cm apart to reduce the risk of tendon disruption [33]. The most distal portion of the Achilles tendon is very thin and narrow and therefore susceptible to rupture or transection of more than half of the tendon fibers. The tendon becomes more substantial at 2 cm proximal to its insertion, making this a good location for incision placement. This incision is also proximal enough to maintain the heel contour, reducing the likelihood of irritation on the heel counter of the shoe [34], and allows access to the plantaris tendon medially. The plantaris tendon can be transected at this level to aide in equinus correction, if required.

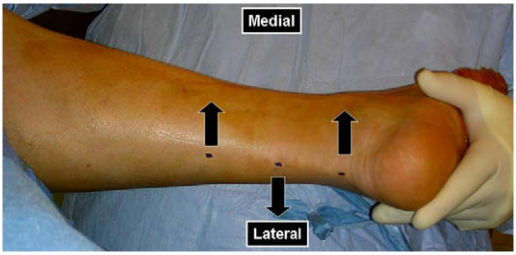


Fig. 3. Assistant positioning the leg for performance of the percutaneous tendo-Achilles lengthening with the knee flexed, the hip externally rotated, and the foot dorsiflexed to allow complete visualization of the posterior ankle and leg. Note the proper incision placement (*surgical scribe marks*) for the standard percutaneous tendo-Achilles lengthening at 2 cm, 5 cm, and 8 cm proximal to the Achilles tendon insertion. The black arrows demonstrate the direction of partial tendon transection.

A No. 64 beaver blade or a No.11 blade is preferred to perform the procedure. An initial percutaneous stab incision is performed in a longitudinal direction at the center of the Achilles tendon 2 cm proximal to its insertion onto the calcaneus. The longitudinal incision is preferred, as it will not gap when ankle dorsiflexion is performed to lengthen the tendon. The blade should advance only through the Achilles tendon proper. The blade is turned medially to transect the medial half of the tendon, which helps to correct any frontal plane hindfoot deformity (ie, varus) present [11]. A second longitudinal stab incision is made 3 cm proximal to the first with the blade turned laterally to incise the lateral half of the Achilles tendon, and then a third stab incision is made 3 cm proximal to the second for transection of the medial half of the tendon. The knee is extended, and the foot is held off the operating room table by the surgeon with the fingers intertwined over the anterior aspect of the ankle and the thumbs pushing up on the plantar aspect of the midfoot (Fig. 4A) while the ankle is rotated into a controlled dorsiflexion (see Fig. 4B), with the goal of the foot reaching 90° to the leg (see Fig. 4C). Excessive force should not be applied to dorsiflex the foot (ie, leaning into the foot with the surgeon's chest (see Fig. 4D) or forcefully pushing the foot into dorsiflexion multiple times (see Fig. 4E)). The Achilles tendon will not be healed completely when the patient begins to ambulate at 4 to 6 weeks postoperatively, allowing additional length to be obtained and thereby adding to the final correction. The desired result is between 0° and 5° of passive ankle dorsiflexion with the knee fully extended. Overlengthening may result in a calcaneal gait and development of a plantar central heel ulcer, especially in a neuropathic patient, which frequently will lead to lower limb amputation [35].

If the desired correction of the equinus deformity has not been achieved, each incision site should be re-evaluated to determine if adequate transection of the tendon has been accomplished in the same manner as described

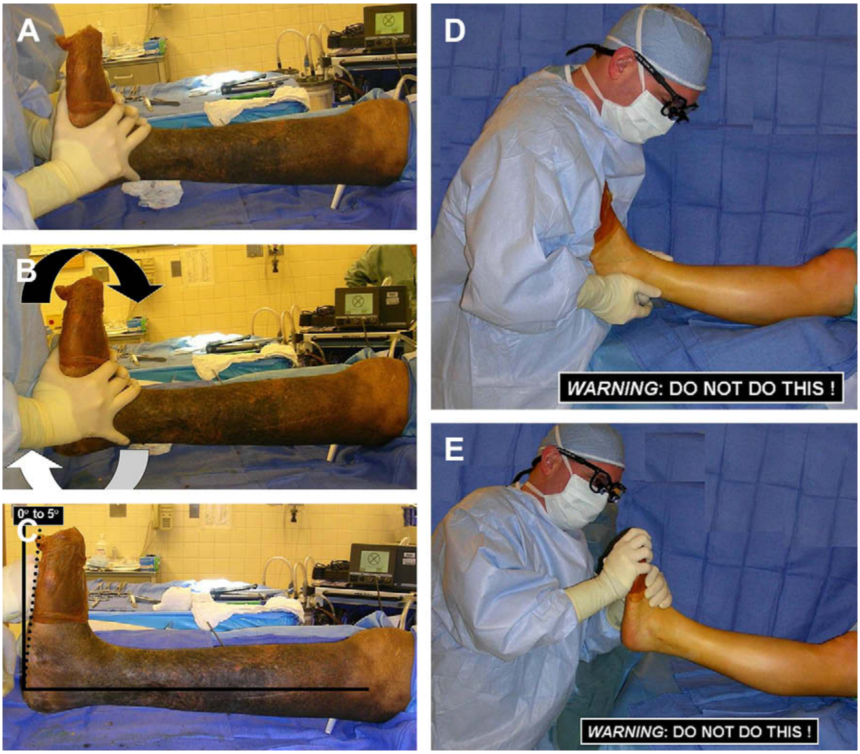


Fig. 4. After performance of the posterior lengthening procedure, controlled dorsiflexion is performed with the knee straight and foot and leg held off the bed while the fingers are intertwined at the anterior ankle (*A*). Steady pressure in a dorsal direction by the surgeon's thumbs across the midfoot is used to rotate the ankle into a corrected position (*B*). The ideal final corrected position is when passive ankle dorsiflexion is between 0° and 5° (*C*). It should be noted that each of the previously mentioned scenarios occurs with the foot at 90° to the lower leg. Excessive force, such as leaning into the foot with the surgeon's chest (*D*) or forcefully pushing on the foot multiple times (*E*) should be avoided to limit the potential for iatrogenic overlengthening or acute rupture of the tendon intraoperatively.

previously. If significant deformity continues, additional incisions can be made at 1 cm intervals between each of the original incision sites, cutting alternating portions of the lateral and medial third of the tendon. Be aware that this will increase the risk of tendon rupture postoperatively because of the added number of incisions within the tendon with a greater likelihood of violating the watershed area. The surgeon should begin with two incisions between the initial distal and middle stab incision sites. Once completed, controlled dorsiflexion should be performed again at the ankle joint. If adequate correction has been achieved, the procedure is complete. If not, two additional incisions can be made between the original middle and proximal incisions as described previously. At this point, controlled dorsiflexion again is attempted. If these maneuvers fail to provide ideal correction, consideration should be given to performing an OGR as will be described, in addition to evaluating the posterior ankle capsule for possible contracture that may prevent reduction of deformity. Skin staples can be used to close each individual incision site, with the foot held in corrected position during application.

The patient then generally is placed into a sugar tong plaster splint, which allows proper immobilization of the midfoot, hindfoot, and ankle, and should be applied with the foot held at 90° to the lower leg. The patient must remain non-weight bearing on the operated side for 4 to 6 weeks or longer depending on what additional procedures are performed. In patients who have peripheral arterial disease or status postperipheral arterial bypass surgery, where postoperative splinting is contraindicated, alternative immobilization of the ankle joint with percutaneous placement of extra-articular Steinmann pins during tendon healing can be performed, as has been described previously [36,37].

Open gastrocnemius recession

OGR is performed with the patient supine and the lower leg externally rotated. Incision placement is determined by marking out the medial aspect of the knee joint and the distal edge of the medial malleolus. The medial aspect of the lower leg is divided into thirds between these two anatomic markers. The incision is placed at the middle of the middle one third of the medial aspect of the lower leg, 2 cm posterior to the posterior most edge of the medial face of the tibia (Fig. 5A). The location can be verified by palpating the medial head of the gastrocnemius muscle (see Fig. 5B), with the incision located just distal to this structure. A 3 cm linear incision is made in this location with a No.10 blade. A hemostat then is placed into the incision and opened in line with the incision site. Care should be taken to avoid disruption of crossing veins that are often present traversing the incision site, which can obscure the operative field. Subcutaneous adipose tissue is swept aside with a moist sponge and the surgeon's index finger. Wide retractors are placed at the edges of the incision, and the deep fascia is visualized. A No.10 blade is used to incise through the deep fascia in line with the skin incision, exposing the underlying gastrocnemius aponeurosis, which then also is incised in the same manner (Fig. 6A). A tissue elevator is passed from medial-to-lateral, identifying the plane between the gastrocnemius aponeurosis and deep fascia (see Fig. 6B), until it is palpated on the lateral side of the leg. As the elevator is removed, it is swept from distal to proximal in a windshield wiper fashion to further define this plane. The wide retractors then are repositioned deep to the deep fascia to fully visualize the underlying gastrocnemius aponeurosis, and a large scissor is used to transect the gastrocnemius aponeurosis from medial-to-lateral (see Fig. 6C). The

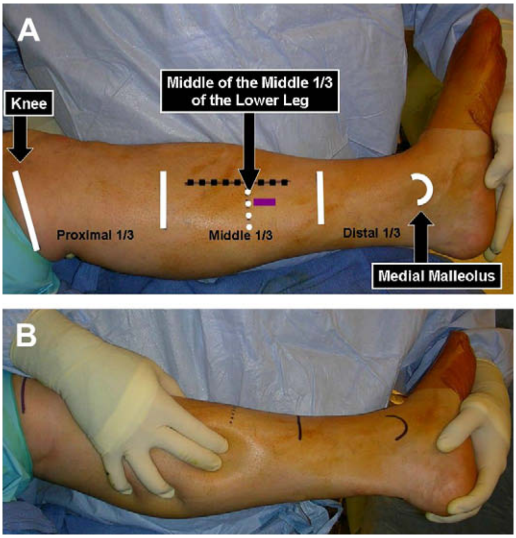


Fig. 5. Landmarks for the open gastrocnemius recession incision are shown with the medial aspect of the leg divided into thirds between the knee joint and the medial malleolus. The incision is placed at the middle of the middle one third of the leg, 2 cm posterior to the posterior edge of the medial face of the tibia (*A*). The location is verified by palpating the medial head of the gastrocnemius muscle (surgeon's index and middle finger) with the incision placed directly distal to this structure (*B*).

plantaris tendon is identified easily as the most medial structure along the medial edge of the gastrocnemius aponeurosis and is transected when visualized. A small portion of the remaining aponeurosis can be visualized at the antero–medial edge of the incision site (see Fig. 6D) and also should be transected with a large scissor, with care taken to avoid injury to the great saphenous nerve and vein that course in close proximity to the tibia at this level of the lower leg (see Fig. 6E). Controlled dorsiflexion of the foot is performed with the knee straight as described in the PTAL procedure, with a goal of getting the foot at 90° to the lower leg. The surgical site is inspected to make certain complete recession of the gastrocnemius aponeurosis has occurred (see Fig. 6F). The incision site then is irrigated with sterile saline, and the calf is compressed to exsanguinate any blood from the surgical site to prevent hematoma formation. An absorbable suture is used to close the deep fascia to avoid adhesion of the skin to the underlying tissues, which can create an unsightly dell at the incision site. The skin is closed with vertical mattress sutures of 2-0 nylon and metallic skin staples. If the procedure is performed in isolation, the patient may be placed into a weight-bearing short-leg boot or walking cast that is kept in place with the foot at 90° to the lower leg for 2 to 4 weeks.

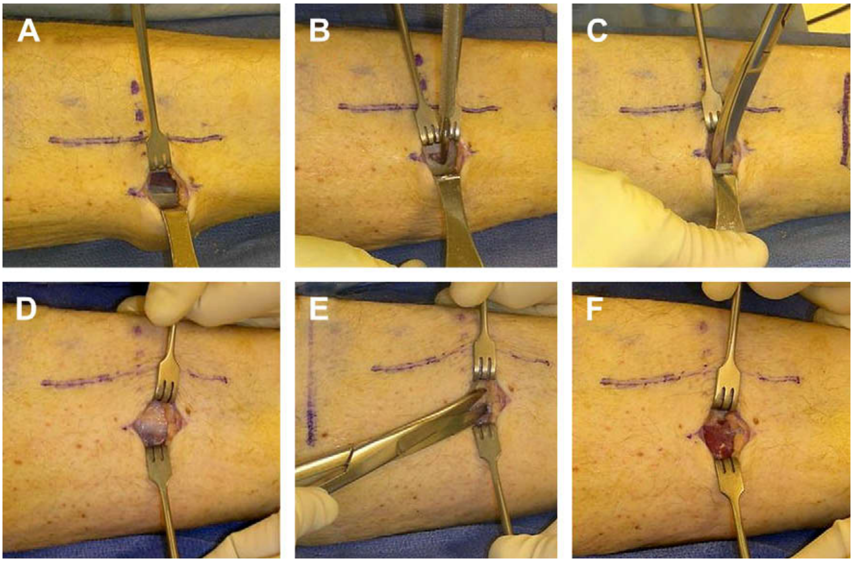


Fig. 6. Incision through the gastrocnemius aponeurosis with the deep fascia retracted and the underlying soleus muscle visualized (*A*). A tissue elevator is passed between the deep fascia and the gastrocnemius aponeurosis to create a safe tissue plane for recession (*B*). A large scissor is advanced to its hub about the gastrocnemius aponeurosis with one blade superficial to the soleus and the other deep to the deep fascia before transection (*C*). Remaining medial fibers of the gastrocnemius aponeurosis are visualized (*D*) and transected with a large scissor (*E*), with care taken to avoid injury to the great saphenous vein and nerve. Completion of the open gastrocnemius recession with visualized soleal muscle fibers (*F*).

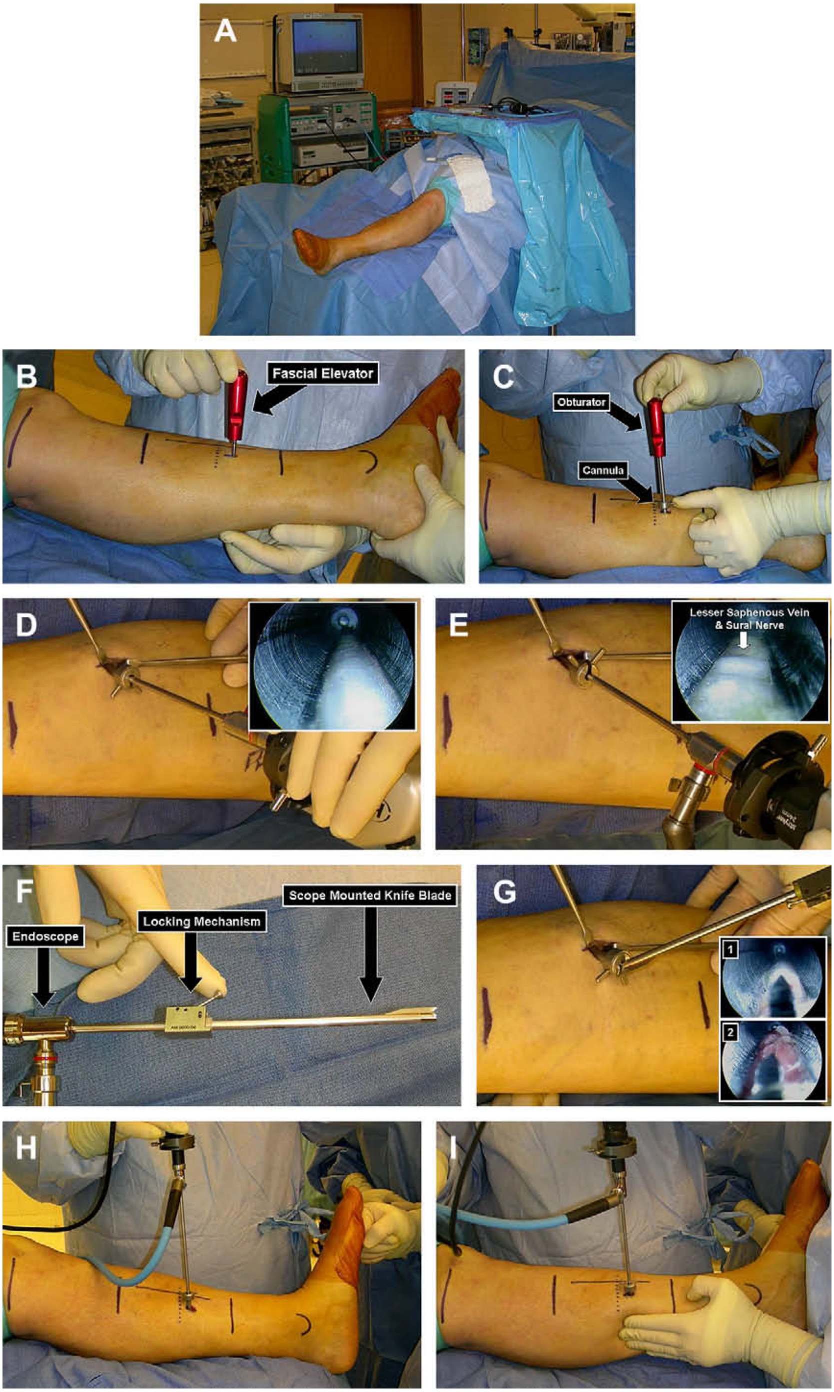
Endoscopic gastrocnemius recession

EGR must be performed with a thigh or sterile high calf tourniquet, as bleeding during the procedure will obscure visualization through the endoscope. The patient is positioned supine with feet at the end of the table, and a stack of towels is placed posterior to the ankle to facilitate passage of instrumentation and dorsiflexion of the ankle during the procedure. The arthroscopy tower is positioned on the contralateral side of the operative limb for easy viewing during the procedure. Care must be taken to avoid knee hyperextension when assessing ankle joint dorsiflexion, as it may limit motion. A second arm board positioned at the end of the bed, on which the contralateral foot can be placed, provides additional room for the endoscopic equipment (Fig. 7A).

An incision of approximately 1 cm in length is required for the EGR and is mapped out in the same manner as for the OGR. A No. 10 blade is used to incise the skin, followed by dissection to the level of the deep fascia as described for the OGR, and incision through this structure to expose the gastrocnemius aponeurosis. The aponeurosis is incised with a No. 10 blade and a fascial elevator (A.M. Surgical Endoscopic Tissue Release, Wright Medical Technology, Incorporated, Arlington, Tennessee) is used to define the plane between the deep fascia and the gastrocnemius aponeurosis from medial-to-lateral (see Fig. 7B). A sweeping motion again is used as discussed previously during removal of the elevator. The obturator and cannula (A.M. Surgical Endoscopic Tissue Release, Wright Medical Technology, Incorporated) are inserted into this plane. The cannula is rotated so that its opening is toward the aponeurosis, and the obturator is removed (see Fig. 7C). A 4 mm, 25° to 30° endoscope is inserted (see Fig. 7D) and slowly advanced from medial-to-lateral to visualize the gastrocnemius aponeurosis and confirm that the cannula is in the correct plane.

The cannula and endoscope then are rotated posteriorly toward the deep fascia. Additionally, the endoscope is withdrawn from lateral-to-medial to visualize the lesser saphenous vein and sural nerve, which frequently do not course in close proximity to each other, to ensure that the cannula lies anterior to these structures to prevent injury to them (see Fig. 7E). Once confirmed, the endoscope and cannula are rotated back 180°, so the opening again faces the gastrocnemius aponeurosis. The endoscope is removed, and the endoscope-mounted knife blade (A.M. Surgical Endoscopic Tissue Release, Wright Medical Technology, Incorporated) is applied to the endoscope and locked in place (see Fig. 7F). The endoscope and knife blade are inserted into the cannula, being careful not to inadvertently incise the skin during entry. The foot is dorsiflexed and the cannula angled slightly toward the gastrocnemius aponeurosis (see Fig. 7G) while the endoscope and knife blade are advanced with both hands in a controlled fashion from medial-to-lateral, incising the aponeurosis (see Fig. 7H). On initiation of the incision, the endoscope and knife blade can be twisted gently from side-to-side to properly engage and begin transecting the medial fibers of the gastrocnemius aponeurosis. Then the instrumentation generally can be advanced through the aponeurosis without significant resistance to complete the release. A stopper on the blade prevents extrusion through the skin at the lateral aspect of the lower leg.

To increase contact between the knife blade and gastrocnemius aponeurosis, the surgeon or his or her assistant can push anteriorly on the posterior calf overlying the cannula while the blade is advanced (see Fig. 7I). The endoscope and knife blade then are removed slowly while the surgeon confirms that complete transection has been accomplished. This is evidenced by visualization of the soleus muscle fibers through the transected edges of the gastrocnemius aponeurosis along its entire course from medial-to-lateral. If portions of the gastrocnemius aponeurosis remain intact, the endoscope and knife blade again are passed through the cannula to incise the remaining regions, being careful not to incise the underlying muscle fibers, which can create excessive bleeding and cause hematoma formation. If visualization becomes obscured at any point in the procedure, the endoscope can be removed and sterile cotton swabs placed through the cannula


A
B
Fascial Elevator
C
Obturator
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Lesser Saphenous Vein
& Sural Nerve
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to clear the operative field. Controlled dorsiflexion of the ankle is performed to assess for correction of deformity. If the correction is inadequate, the endoscope and knife blade are removed, and irrigation is performed through the cannula. The obturator then is placed into the cannula, and both the obturator and cannula are removed to prevent trauma to the soft tissues. A large scissor is used to transect the medial most fibers of the gastrocnemius aponeurosis at the anterior border of the incision site as described previously. If additional correction is required, elevation of the gastrocnemius aponeurosis off of the underlying soleus can be achieved with a tissue elevator. Although described in the literature, use of an accessory lateral incision should be avoided to prevent iatrogenic injury to the superficial peroneal nerve, which courses through the lateral compartment of the lower leg [38]. The deep fascia is closed with absorbable suture for the reasons described previously, followed by skin closure, also described previously. If performed as an isolated procedure, the postoperative course is identical to that for the OGR.

Summary

Soft-tissue ankle equinus contracture contributes to the etiology of multiple foot disorders and must be addressed to achieve global correction of deformity. A sound understanding of the indications for each procedure, the relevant topographic anatomic landmarks for incision placement, and the operative technique will aide the surgeon in achieving the best possible results. There is potential for complications with any of the described techniques. Appropriate procedure selection for the individual patient, however, with care to avoid overlengthening in the operating room, along with protection of the involved extremity postoperatively leads to reproducible success with these procedures even in the high-risk patient.

Fig. 7. Intra-operative photograph demonstrating proper set-up for performing an endoscopic gastrocnemius recession (*A*). Insertion of the fascial elevator between the deep fascia and gastrocnemius aponeurosis (*B*). Insertion of the cannula and obturator into the developed plane superficial to the gastrocnemius aponeurosis and deep to the deep fascia (*C*). The cannula will remain after removing the obturator. With the cannula rotated toward the aponeurosis, a 4 mm, 25° to 30° endoscope is inserted to visualize the gastrocnemius aponeurosis across its full width from medial-to-lateral (*D*). Once the gastrocnemius aponeurosis has been visualized, the endoscope and cannula are rotated posteriorly toward the deep fascia to withdraw from lateral-to-medial, with care taken to identify the sural nerve and lesser saphenous vein within the adipose tissue (*E*). The locking mechanism is applied to the scope-mounted knife blade, and both are inserted onto the endoscope (*F*). The foot is held in dorsiflexion to place tension on the gastrocnemius aponeurosis by the assistant (*G*), and the endoscope and knife are angled toward the aponeurosis during advancement to transect the gastrocnemius aponeurosis (*H*). An assistant also can increase contact between the knife blade and gastrocnemius aponeurosis by pushing the cannula anteriorly on the posterior calf while the blade is advanced (*I*).

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