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A review of salvage procedures after failed Achilles tendon repair

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Etiology and epidemiology

Treatment of Achilles tendon rupture was first reported by Ambroise Paré in 1575. Treatment was primarily nonsurgical until the twentieth century. Surgical intervention gained popularity in the 1920s, primarily because of reports by Abrahamson in 1923 and Queru and Staianovich in 1929 that described good results [1].

Treatment options for the ruptured Achilles tendon can be classified broadly as operative and nonoperative. Operative treatments can be subdivided into percutaneous and open procedures. Despite developments in operative techniques and biomaterials, the best method of treatment is still debated fiercely. For the last 20 years, open repair has been the procedure of choice for younger, active patients and patients with chronic rupture that require reconstructive procedures. The advantages of surgical treatment are the low incidence of reruptures and the stronger tendon; disadvantages are the high rate of complications such as infection, delayed healing, adhesions, and reduced ankle joint mobility [2,3].

The Achilles tendon is one of the most commonly injured tendons in the human body and is the most often ruptured tendon [4]. The Achilles tendon and the patellar tendon are the two most frequently injured tendons as a result of overuse. Rupture of the Achilles tendon is being reported more frequently in the literature, possibly secondary to a true increase in incidence with greater participation of the general population in physical activities, or because of an increased awareness of the problem. The male-to-female ratio has been reported by Carden et al [5] to range between 2:1 and 19:1. Myerson [6] cited a ratio of 30:1 in clinical experience. It has been reported repeatedly that more than 75% of Achilles tendon ruptures occur during a sports-related activity. Additionally, Achilles tendon

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rupture is more prevalent in industrialized countries, where lifestyles are more sedentary and where athletic participation has increased dramatically [7].

Achilles tendon rupture is related to the mechanical loading that is imposed on it during physical activity; the tendon is unable to withstand the mechanical loading that is associated with increased physical activity. Discontinuity of the tendon can result from a direct blow, laceration, or by indirect rupture, which is the most common cause. Indirect rupture can occur at any point in the tendon or at the musculotendinous junction as the result of sudden, forceful stress. Traumatic rupture usually results from a direct blow to a stretched tendon, a laceration, or from gunshot wounds. The use of corticosteroids was associated with collagen necrosis and an increased risk of rupture [8]. Other reported causes of rupture include gout [9], hyperthyroidism and renal insufficiency [10], arteriosclerosis [11], and fluoroquinolone antibiotics [12].

Ruptures of the Achilles tendon are believed to result from a combination of events that are based on an underlying hypovascularity that result in subsequent degeneration and weakening of the tendon. Theoretically, this leads to increased susceptibility to failure at lower than expected applied stresses [13].

Diagnosis

The diagnosis of Achilles tendon rupture is often missed. There are several diagnostic tests for assessing the continuity of the Achilles tendon including: the Thompson calf-squeeze test, needle test, knee-flexion test, and the sphygmomanometer test. The calf-squeeze test was described in 1962 [14]. With the patient prone on the examining table and the ankles clear of the table, the examiner squeezes the fleshy part of the calf. Squeezing the calf deforms the soleus muscle, which causes the overlying Achilles tendon to bow away from the tibia and results in plantar flexion of the ankle if the tendon is intact. The affected leg should always be compared with the contralateral leg. A false-positive finding is possible in the presence of an intact plantaris tendon.

The knee-flexion test is performed by asking the patient to actively flex the knees to 90° while lying prone on the examining table. If the foot falls into neutral or dorsiflexion during this maneuver, an Achilles tendon rupture can be diagnosed [15].

The needle test is performed by inserting a hypodermic needle through the skin of the calf, just medial to the midline and 10 cm proximal to the insertion of the tendon. The needle is inserted until its tip is just within the substance of the tendon. The ankle is then alternately placed in plantar flexion and dorsiflexion. If the needle points distally on dorsiflexion, the portion of the tendon distal to the needle is presumed to be intact. Conversely, if the needle points proximally, a loss of continuity between the needle and the site of the insertion of the tendon can be presumed [16].

The sphygmomanometer test is performed by wrapping a sphygmomanometer cuff around the midportion of the calf while the patient is lying prone. After

inflating the cuff to 100 mm Hg with the foot in plantar flexion, the foot is dorsiflexed; if the pressure rises to approximately 140 mm Hg, the musculotendinous unit is presumed to be intact. If the pressure does not rise with dorsiflexion, the Achilles tendon is ruptured [17].

Treatment

Studies have shown a marked increase in the incidence of complications after nonsurgical treatment, such as a decrease in plantarflexion when compared with the opposite foot, reduced strength, and more frequent rerupture [18]. Therefore most surgeons currently advocate limiting nonsurgical treatment to sick or sedentary patients, or patients with limited functional and athletic goals.

A direct primary repair is preferable. Over time, scarring and contracture of the gastrocnemius–soleus complex makes primary repair an unlikely option. After excising scar tissue, a sizable gap can result and preclude an end-to-end repair; this makes other reconstructive procedures necessary.

Multiple treatment modalities have been described for patients with chronic rupture or a rerupture that is not repairable primarily. Some investigators turned down a strip of the tendon or bridged the defect with a graft of fascia lata. Others recommended transfer of the peroneus brevis, the plantaris, flexor digitorum longus, or flexor hallucis longus. Additionally, synthetic materials, such as Dacron polyester or carbon fiber, have been used as scaffolding for the formation of the scar of repair. More recently, pig submucosa (Restore, DePuy, Warsaw, IN) has been developed to augment Achilles tendon defects.

Peroneus brevis transfer

Teuffer [19] published the peroneus brevis transfer technique in 1974. The technique begins with dissecting the Achilles tendon through an external, longitudinal incision and exposing the posterior pole of the calcaneus. A small incision is made at the base of the fifth metatarsal and the tendon is detached from the lateral peroneus brevis, which is brought out in the upper part of the first incision; the aponeurotic septum separating the lateral from the posterior compartment is excised. Next, the posterior pole of the calcaneus is dissected and a hole of sufficient diameter is drilled to permit the free passage of the tendon. Finally, the lateral peroneus brevis is passed through this hole making a "U" shape and its distal end is fixed on the proximal end of the Achilles tendon and to the peroneus itself.

Hepp et al [20] reported good or excellent results with the peroneus brevis transfer in eight patients over a 5-year period. The patients were very satisfied and returned to a comparative level of preoperative activity. Wound healing complications occurred in two cases without disturbing the functional results. Gallant et al [21] objectively evaluated the eversion and plantar flexion strength after peroneus brevis transfer in eight patients; they found mild eversion weakness but no plantar flexion weakness. Subjective assessment showed no

functional compromise in eversion strength, plantar flexion strength, activities of daily living, or ankle stability. Pintore et al [22] presented the results of a single-center, single-surgeon study that included 59 patients with a fresh or neglected Achilles tendon rupture. Patients were assessed 6 weeks and 6 months post-operatively. Patients were generally satisfied with the procedure, but those with a neglected rupture tended to have a greater postoperative complication rate, less isokinetic strength variables at high speeds, and smaller calf circumference. The investigators concluded that peroneus brevis transfer is a safe, but technically demanding, procedure, and it affords good recovery. Patients with a neglected rupture are at a slightly greater risk of postoperative complications and their ankle plantar flexion strength can be reduced.

Flexor digitorum longus graft

Mann et al [23] described a technique for repairing the Achilles tendon using the flexor digitorum longus as the graft. With the patient in the prone position, an 8cm to 10 cm, hockey-stick-shaped incision is made proximally, medial to the tendon, continued distally and then turned gently laterally, distal to the insertion of the tendon. The tendon sheath is opened at the site of rupture, and the location and characteristics of the rupture are ascertained. Next, a 7 cm incision is made, starting on the medial aspect of the foot just distal and inferior to the navicular bone and extending along the upper border of the abductor hallucis toward the first metatarsophalangeal joint. After dissection dorsal to the abductor hallucis to allow the muscle to be retracted plantarward, the flexor hallucis longus and flexor digitorum longus are identified. Visualization of these tendons can be enhanced with the release of the Knot of Henry. During dissection it is crucial to show the location of the digital branches of the flexor digitorum longus. Next, the tendon of the flexor digitorum longus is cut just proximal to its division, into separate digital branches. The proximal aspect of the distal stump of the flexor digitorum longus is then sutured to the adjacent intact flexor hallucis longus tendon. The lesser toes are held with the interphalangeal joints in neutral extension to prevent tension on the anastomosis. The proximal part of the flexor digitorum longus tendon is pulled back into the proximal part of the wound, just posterolateral to the neurovascular bundle, and its sheath is freed to allow it to be placed adjacent to the Achilles tendon. Next, a transverse hole is drilled through the posterior aspect of the calcaneus; and with the foot in approximately 10° to 15° of plantarflexion, the tendon of the flexor digitorum longus is passed through the drill hole in a medial-to-lateral direction and is sutured to itself with a non-absorbable suture. A central slip from the proximal portion of the Achilles tendon is mobilized and brought down to the distal stump in the calcaneus, just anterior to the original insertion of the Achilles tendon. The slip is then cross-sutured to the flexor digitorum longus tendon. If length allows, the proximal stump of the Achilles tendon is reattached to the calcaneus with a pullout wire technique.

Mann et al [23] reported the results of repair with flexor digitorum longus graft in seven patients followed postoperatively for an average of 39 months. The

result was excellent or good in six patients and fair in one. Postoperatively, one patient needed a local rotation flap and another needed a split-thickness skin graft; both procedures resulted in excellent restoration of function. The patient who had a fair result had a persistent limp and residual discomfort. There were no reruptures.

Flexor hallucis longus

Hansen [24] described a new technique for reconstruction of chronic Achilles tendon rupture using the flexor hallucis longus. With the patient in the supine position, a longitudinal incision is made along the medial border of the midfoot, from the navicular to the head of the first metatarsal for harvest of the flexor hallucis longus tendon. The skin and subcutaneous tissues are divided sharply down to fascia. The abductor is then reflected plantarward with the flexor hallucis brevis, exposing the deep foot anatomy. The flexor digitorum longus and flexor hallucis longus are identified within the midfoot. Next, the flexor hallucis longus is divided as far distally as possible which allows an adequate distal stump to remain for transfer to the flexor digitorum longus. After the proximal portion is tagged with a suture, the distal limb of the flexor hallucis longus is sewn into the flexor digitorum longus with all five toes in neutral position which allows flexion to all five toes through the flexor digitorum longus. A second longitudinal incision is made posteriorly at the medial aspect of the Achilles tendon, starting from the level of the musculotendinous junction and extending to 1 inch below its insertion on the calcaneus. This incision is carried down to the level of the tendon. The paratenon is opened longitudinally and the tendon is inspected. The fascia that overlies the posterior compartment of the leg is incised longitudinally and the flexor hallucis longus is retracted from the midfoot into the posterior incision. Next, a medial-to-lateral drill hole is placed just distal to the previous insertion of the Achilles tendon halfway through the bone. A second vertical drill hole is made deep to the insertion of the Achilles tendon to meet the first hole. A suture passer is placed through the tunnel from distal to proximal. The tag suture is passed through the tunnel which pulls the flexor hallucis tendon through the drill hole. The flexor hallucis longus tendon is woven from distal to proximal through the Achilles tendon using a tendon weaver, which is then passed through the Achilles tendon to create a ''tunnel'' in the tendon. The tag suture on the flexor hallucis longus is grasped and pulled back through the tunnel which brings the flexor tendon through the Achilles. In complete ruptures of the Achilles, the flexor is used to bridge the gap and tension is secured with the foot in approximately 10° of plantarflexion. The weave is secured with multiple No. 1 cottony Dacron. After completion of the reconstruction, the tendon paratenon is repaired and the subcutaneous tissue and skin are closed.

Wapner et al [25] evaluated seven patients over 17 months after repair of Achilles tendon rupture with flexor hallucis longus transfer. There were no postoperative infections, skin losses, or reruptures. Each patient developed a small, but functionally insignificant, loss in the range of motion in the involved ankle and great toe. All patients had a satisfactory return of function. Wilcox et al [26]

reported the results of flexor hallucis longus tendon transfers in 20 patients who were followed for 14 months. There were no postoperative reruptures, tendinopathy recurrences, or wound complications. Despite a small loss of calf circumference, range of motion, and plantar flexion strength, 90% of patients scored 70 or higher on the American Orthopaedic Foot & Ankle Society (AOFAS) scale.

V-Y tendinous flap

Bosworth [27] described a method of end-to-end anastomosis of ruptures of the Achilles tendon using a V-Y tendinous flap technique. This technique is ideally suited for larger (approximately 2–5 cm) defects. With the patient in the prone position, a lazy-S incision is made from the lateral aspect of the Achilles tendon insertion to the middle third of the calf, the sural nerve is retracted, and the deep fascia is incised in the line of the incision. The paratenon may be found bridging the ends of the ruptured tendon. If so, this is incised longitudinally and the scar tissue at the site of the tendon rupture is excised carefully. The paratenon is later used to cover the anastomosis. After the tendon ends are trimmed appropriately, the length of the defect in the tendon is measured with the knee in 30° of flexion and with the ankle in 20° of plantarflexion. The apex of the inverted V incision is made over the central part of the aponeurosis. The arms of the V incision should be at least one and one-half the length of the defect in the tendon to allow for suturing in a Y configuration. The arms of the incision extend through the aponeurosis and underlying muscle tissue along the sides of the flap. Next, the flap is pulled distally until the ruptured ends of the tendon are approximated. The ruptured ends are sutured with interrupted stitches of nonabsorbable suture material. The paratenon is sutured with interrupted stitches of chromic catgut and the deep fascia and subcutaneous tissue are also approximated with plain catgut. After skin closure, a long cast is applied with the knee at approximately 30° of flexion and the ankle at approximately 20° of plantar flexion.

Plantaris tendon

Lynn [28] described reconstruction of the Achilles tendon using the plantaris tendon. With the patient in the prone position, an incision is made along the medial border of the heel cord from its point of insertion on the calcaneus and extending approximately 5 to 7 inches proximally. Through careful dissection, the subcutaneous tissue is separated from a fascial sheath that overlies the tendon and is continuous with the fascia lata. The sheath is incised in the midline. The foot is plantarflexed and the ruptured ends of the tendon are approximated without excising any of the tendon. The ends of the ruptured tendon are overlapped and sutured with fine chromic catgut. If the plantaris tendon is intact and normal in appearance, it is simply detached from its insertion in the calcaneus and fanned out from distal to proximal to the extent necessary to form a membrane that is sufficient to wrap around the anastomosis. The

membrane is then sutured in place. If, however, the plantaris is ruptured along with the Achilles tendon, it must be drawn distally to bridge the anastomosis. A small incision is then made in the mid-calf, at a level where the proximal portion of the plantaris tendon can be identified and sectioned transversely. The free segment of the tendon is drawn distally into the initial wound. This slip of tendon is stretched into a tough membrane as previously described and sutured around and to the Achilles tendon as a free graft; it should cover the site of rupture completely and the tendon itself, and provide a smooth, strong reinforcement to the suture line. After completion of the repair, the fascial sheath is enclosed with interrupted sutures of fine catgut. The most distal part of the sheath is left open to prevent undue tension. The subcutaneous tissues and skin are then closed in layers with sutures of 00 catgut.

Dekker and Bender [29] reported excellent or good results of repair using plantaris tendon in 19 patients. Quigley and Scheller [30] evaluated 40 patients over a 19-year period. Subjectively, the results were excellent as graded by the patients; objectively, there were some minor deficits that did not impede the overall function. The clinical results were rated excellent (42%), good (36%), fair (15%), and poor (6%).

Fascia lata

In 1940, Zadek [31] described using fascia lata strips for Achilles tendon reconstruction. With the patient in the prone position, the Achilles tendon and the distal portion of the gastrocnemius muscle are exposed through a posterior lateral incision. Any interposed scar tissue is debrided to normal tendon proximally and distally. A sheet of fascia lata that measures 3 inches by 6 inches is obtained from the ipsilateral or contralateral thigh. Three strips of fascia that are 3/8 inch wide are cut from the large sheet in the long axis. The foot is held in plantar flexion and traction is applied to the proximal stump with a large transfixing wire suture. The three fascial strips are sutured into the proximal stump with a Gallie fascial needle. Each graft is sutured back to itself and to the tendon with several interrupted sutures. The first strip extends from the medial portion of the proximal stump to the lateral part of the distal stump. The second strip extends obliquely in the opposite direction following the normal rotation of the fibers of the tendon. The third strip is sutured in the midline and the remaining large fascial sheet is sutured around these grafts in a tube-like fashion. Next, the large wire suture in the proximal stump is developed into a ''pull-out suture'' through the heel pad. The wound is closed in layers and a long-leg cast is applied with the knee in 40° of flexion and the foot in 20° of plantar flexion.

Complications

Complications after repair of the Achilles tendon include wound infection, skin necrosis, sural neuroma, rerupture, and adhesion of the skin to the repaired

tendon. Wills et al [32] reviewed 775 patients who were treated surgically for rupture of the Achilles tendon. They found a 20% incidence of complications, many of which were related to wound healing. Meticulous hemostasis and careful closure technique can help to avoid devastating complications. Wound closure after Achilles tendon repair is usually difficult because of local tissue swelling and bulk of the repaired tendon. Subsequently, tension on the wound edges increases the likelihood of wound complications. An anterior-based splint, with all pressure off the posterior wound while in bed, can reduce the incidence of wound complications.

Infection and wound healing issues can be devastating complications because the options for soft-tissue coverage over the Achilles tendon are very limited. Split-thickness skin grafts are rarely suitable because of the relative avascularity of the adjacent tissue. In addition, incorporation of the graft over the exposed tendon is unlikely.

If soft-tissue coverage of the repair becomes an issue because of infection or flap compromise, microvascular free flaps are the procedures of choice. The two most common are the radial forearm flap and the latissimus dorsi muscle free flap. They can be used to reconstruct medium and large defects and to provide gliding tissue for the Achilles tendon. The complication rate of microvascular flaps is comparable to that of local flaps but microvascular flaps are technically more demanding. Radial forearm free flaps offer the advantage of thin, supple, vascularized tissue. The flap can also be elevated easily for secondary reconstructions. Latissimus dorsi muscle free flap is more suitable for larger and more extensive defects, including distal calf muscle to the plantar metatarsal area. This flap is advantageous because it allows for a single procedure, is adaptable to a wide range of defects, and it permits faster wound healing supported by well-vascularized tissues. The latissimus dorsi flap results in satisfactory function of the ankle joint, has a padding effect, and produces good contour of the posterior calf to the sole with acceptable donor site morbidity.

Summary

The most common complications that are associated with delayed repair of the Achilles tendon are rerupture, wound necrosis, infection, and inability to regain dorsiflexion. Wound complications can be avoided by using meticulous soft-tissue handling techniques, full-thickness flaps when necessary, and minimal pressure to the wound postoperatively. Ankle stiffness may be reduced by ensuring that the repair does not place undue tension on the tendon which requires the ankle to be placed in excessive plantarflexion.

Good restoration of function can be obtained by surgical intervention. Regardless of the size of the defect, etiology, or delay in treatment, the salvage procedures described can successfully restore strength and function. It is imperative, however, that patients take an active role in their rehabilitation and remain motivated throughout their course of postoperative therapy.

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