Initial Clinical Experience with the Use of Human Amniotic Membrane Tissue During Repair of Posterior Tibial and Achilles Tendons

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INTRODUCTION

Connective tissues that become damaged or diseased can result in reduced mobility and contribute to the development of chronic pain.[1] While conservative treatment approaches are often helpful, many patients become debilitated and require surgical intervention. As a result of the widespread prevalence of these conditions, procedures to repair and reconstruct damaged connective tissue are commonplace. While these procedures are usually successful, the healing of damaged tendons and ligaments following surgery is particularly difficult often resulting in the failure of the tendon or ligament to regain its original strength.[2,3]

The formation of adhesions between the tendon and its sheath and/or the soft tissue surrounding the tendon following surgery is also problematic. These adhesions can delay healing and rehabilitation since they produce resistance to the gliding motion between the tendon and soft tissue resulting in reduced range of motion and increased post-operative pain.

Several strategies designed to accelerate the repair of tendons and ligaments have been studied with none having achieved the expected results to date.[4,5] A number of collagen matrix products designed to provide reduce scarring and improve tendon gliding post-operatively are also commercially available. Unfortunately, there are no published peer-reviewed studies that demonstrate the clinical benefit of collagen matrix products for this use. As a result, there is continued interest in identifying alternative solutions for reducing complications and improving rehabilitation following tendon surgery.

A novel allograft composed of human amniontic tissue has recently been introduced for use in tendon surgery (AmnioClear™, AFCell, Fort Wayne, IN). As a result of its unique biologic properties[6], we have recently begun using human amniotic membrane tissue as an alternative for wrapping tendons during surgery for posterior tibial tendon dysfuction (PTTD) and Achilles tendon repair procedures in order to reduce adhesion formation and improve tendon gliding.

AMNIOTIC MEMBRANE TISSUE

Human amniotic membrane, the innermost lining of the placenta, consists of a single layer of epithelial cells, a thick basement membrane, and an avascular stroma. The amnion is immunologically privileged and has low immunogenicity.[6] Amniotic membrane tissue has demonstrated anti-adhesive, anti-inflammatory and antimicrobial properties.[7-14]

The clinical use of human amniotic membrane tissue has been studied since the early 1900's.[15,16] Since that time, numerous authors have reported on the potential clinical benefit of using amniotic membrane tissue for a variety of clinical applications including but not limited to wound healing, the management

of burns, and the prevention of adhesions.[8-10,17,18] Since the mid-1990's there has been a growing use of amniotic tissue to reduce scarring and inflammation in association with ocular repair.[19,20] More recently amniotic membrane tissue has been used during periodontal surgery to treat gingival recession.[21]

The use of amniotic membrane tissue for tendon repair has also been studied by several authors. Reports from differing experimental models have indicated that the use of amniotic tissue can prevent adhesion formation without affecting tendon healing.[17-19]

Based on its anti-adhesive, anti-inflammatory and anti-microbial properties and the history of use for other clinical procedures, we have begun an initial assessment of amniotic membrane tissue for tendon wrapping during select foot and ankle procedures.

The following is a report of two clinical cases where human amniotic tissue was used for this purpose. The amniotic membrane product we used is commercially available and supplied in sterile packaging as a dry amniotic membrane patch (4 x 4 cm).

Case #1

Medical History

The patient was a 47-year-old woman who presented with a complaint of tenderness in the medial aspect of her right ankle which also occasionally radiated distally into her foot for a period of 6 months. The patient indicated that the pain increased during ambulation and prolonged periods of activity. According to the patient, the pain was not related to any trauma to the foot. The patient noted that she had experienced a progressive flattening of her arch over the past few months. Self-prescribed acetaminophen and ibuprofen did not provide pain relief. The patient's medical history revealed hypertension treated with a beta blocker, no previous surgeries and no known drug allergies.

Physical Exam

Upon physical exam the patient had considerable tenderness along the course of the posterior tibial tendon, from just behind the medial malleolous to its insertion into the navicular. There appeared to be a normal range of motion of the ankle joint as well as the subtalar and midtarsal joints. Manual muscle testing revealed all groups to be full strength except for some weakness of the foot on resistance against inversion with some pain as well during this maneuver. On standing the patient appeared to have an abducted forefoot on the rearfoot especially on the right foot. The patient also had an obvious inability to rise up on her toes on the right foot.

Imaging Studies

MRI demonstrated a thickening of the tibialis posterior tendon. There was an increase signal circumferentially with tendon sheath effusion. The intratendinous signal was also increased. Radiographs in the lateral view demonstrated a loss in the longitudinal arch with a first ray elevatus and break in the cyma line. The talus was plantarflexed and the calcaneal inclination approached the parallel weight-bearing surface. No osteoarthritic findings were noted.

Diagnosis

Based on the patient history, physical exam and imaging results a diagnosis of posterior tibial tendon dysfunction was made.

Tibialis Posterior Tendon Dysfunction

In the present patient the early and accurate diagnosis of posterior tibial tendon dysfunction was paramount to preventing progression of deformity. Posterior tibial tendon dysfunction has been diagnosed more often over the past several years. This is likely a result of this condition having been misdiagnosed or at least under-diagnosed previously. A recent increase in the reporting of this condition in the literature has made its signs and symptoms more easily recognizable.

The posterior tendon's main function occurs during the stance phase of gait where at heel strike it aids in resisting and slowing rearfoot eversion. As the foot progresses into midstance the tendon helps lock the midtarsal joint and begins contracting to cause subtalar joint inversion. Finally, in the propulsive phase of gait the tendon accelerates subtalar joint inversion ands in heel lift. So simply put the posterior tibial tendon is the main inverter of the foot and is largely responsible for maintaining arch height.

There has been some controversy as to the cause of posterior tendon dysfunction. It generally involves a degeneration of the tendon from a multitude of causes. The overall cause is usually multifactorial in nature. Some structural abnormalities, alone or in combination, which may lead to its development include an accessory navicular, rigid or flexible flatfoot, and equinus. Along with a theory regarding the zone of relative dysvascularity within the tendon between the medial malleolous and the tendon insertion, the aforementioned, leads to degeneration within the tendon. As the tendon degenerates it begins to slowly elongate and eventually loses mechanical advantage. This loss of mechanical advantage allows the peroneus brevis to gain advantage and causes loss of arch height and midtarsal joint break.

Various classifications and staging systems have been proposed for the progression of the deformity. Stage 1 is considered an asymptomatic period where the patient has nothing more than an underlying structural or anatomic abnormality that predisposes them to the development of posterior tendon dysfunction. As the patient progresses into stage 2 they usually develop symptoms that lead to seeking medical attention. Symptoms include tendinitis, some effusion behind the medial malleolous, and progression of a flat foot deformity. The patient will have tenderness along the course of the tendon, abduction of the forefoot, and failure to successfully rise up on their toes on one side. Stage 3 is similar to the 2nd stage with more disabling symptoms and greater degeneration within the tendon be it longitudinal tears or partial ruptures. Finally in stage 4 the patient begins to experience joint adaptation and functional disability.

Diagnosis can generally be made on the patient's history and a good clinical exam. Radiographs can be useful to assess joint adaptations in later stages of dysfunction and are useful in surgical planning. The MRI has become a useful tool to assess the pathology within the tendon, that is, whether a simple tenosynovitis exists or whether the dysfunction has progressed to midsubstance tears and partial ruptures. This again may aid in surgical planning.

Treatment is generally based on the stage of dysfunction. Mild stage 1 dysfunction can in certain cases be treated conservatively. The underlying biomechanical abnormality must be controlled to prevent further progression of the deformity. This is generally accomplished with some type of orthotic device with a high degree of varus posting. NSAID's and physical therapy may have some benefit as well. Once the dysfunction progresses into the later stages surgery becomes the only viable option. Surgical intervention starts with direct tendon repair and progresses into tendon transfers and finally to bony reconstruction including calcaneal osteotomies, subtalar arthroereisis procedures, with the last step being a triple arthrodesis.

Surgical Procedure

Based on the patient diagnosis and progression of her condition, a decision was made to surgically repair her posterior tibial tendon. After the patient was appropriately prepped and an initial incision was made, the posterior tibial tendon sheath was identified and incised (Fig. 1). The tendon was noted to have marked adhesions and vinculae attachments connecting the tendon to the entire sheath from the medial malleolus and distally to the insertion at the medial tuberosity of the navicular. All of the

adhesions, vinculae were removed and the surface tears of the tendon were excised.

Fig. 1. Posterior tibial tendon.

The tendon was inspected into the central intra-substance body and the entire necrotic tendon present was surgically removed. The tendon was then closed in an inverted tubular fashion with 4-0 Vicryl suture. The internal surface presented with a marked amount of reactive sinusitis tissue, this was derided.

Fig. 2. Application of amniotic membrane to posterior tibial tendon following tendon repair

The repaired tendon was then wrapped with amniotic membrane tissue to prevent tendon-sheath interface adhesion and reduce the risk of inflammation (Fig. 2). The membrane was wrapped directly around the tendon in the area of suspected adhesion, the excess was cut with tenotomy scissors (Fig. 3). The material adheres by surface tension and quickly reconstitutes and rehydrates and obviates the need for suturing.

The sheath was closed with 4-0 Vicryl and deep closure with 2-0 Vicryl and skin with 4-0 Biosyn followed by the application of a dry sterile dressing.

Fig 3. The posterior tibial tendon wrapped with amniotic membrane prior to wound closing.

The patient was placed into a below the knee cast for 3 weeks, followed by a cam walker. Physical therapy to increase strength and motion started on the 4th week. The patient continues to ambulate now without assistance and has minimal discomfort.

Case #2

Medical History

The patient was a 55-year-old man who presented with a five-month history of posterior superior right heel pain. The patient noticed occasional sharp shooting pain in his right heel that began as remitting but eventually progressed to constant tenderness approximately 3-4 weeks after the onset of initial symptoms. Irritating pain, swelling, and tenderness were present with both ambulation and non-weight bearing, but were aggravated with activity. The patient denied any pre-cipitating activity or history of trauma to the area. Self-treatment consisted of anti-inflammatory medication.

Physical Exam

Upon examination, the patient's tendo-achilles was indurated and swollen with an increase in

the diameter of the right ankle as compared to the left. The patient experienced pain upon palpation of the posterior superior aspect of right Achilles tendon at its insertion that traveled proximally 15 cm. The patient had a palpable defect and separation in the tendo-achilles with an increase in separation when the foot was dorsiflexed. He also had a non-tender plantar fascia or plantar medial tubercle of calcaneus with no signs of crepitus on range of motion of the right achilles tendon. The patient had discomfort with dorsiflexion and plantarflexion of the right ankle posteriorly, and manual muscle testing of lower extremity yielded a decreased plantarflexory power of the right ankle.

Imaging Studies

T2 weighted MRI images of the right ankle and foot showed a lack of homogenicity with multiple intratendinous splits and presence of intratendinous fluid within the Achilles tendon. An increased thickness of Achilles tendon and decrease in signal intensity within the tendon approximately 5-15 cm from Achilles insertional area was observed on T1 weighted images.

Diagnosis

Based on the patient history, physical exam and imaging results a diagnosis of chronic total tendo-Achilles rupture was made.

Tendo Achilles Rupture

Posterior superior heel pain can encompass many entities. A thorough history and physical, as well as the utilization of radiographic examination such as plain film radiography, bone scan, and MRI can help narrow a differential diagnosis.

The diagnosis of chronic Achilles tendon tear is based on the patient's symptoms, the physical exam and many times magnetic resonance imaging. There are several hypotheses regarding the cause of Achilles tendon rupture. Intratendinous steroid injections, mucoid degeneration and micro tears within the tendon, intensive physical training without proper warm-up, chronic tendinous inflammation or tenosynovitis, and retrocalcaneal spurring are some of the more recognized etiologies that have been linked to achilles tendon rupture.

When the diagnosis of chronic Achilles tendon rupture is made the physician must then implement a treatment course. Conservative therapy is often utilized first, which often consists of a combination of NSAIDS, rest, physical therapy (such as phonophoresis, prorprioceptive exercises, ultrasound, ice, whirlpool), accommodative padding, heel lifts, and functional orthotics. If conservative care is exhausted without any significant relief in symptoms, then surgical intervention is usually employed. In this case it was obvious that the tendon was disrupted and this obviated the need for conservative care and led to immediate open repair.

Surgical treatment typically involves tendon repair and tenolysis. Various surgical techniques and postoperative protocols have been established and refined thru the years that have proven to be effective.

Surgical Procedure

After the patient was appropriately prepped, an initial incision was made over the tendo achilles. In this particular case the entire paratenon and tendon were non-existent in this distal portion of the insertion of the tendon. The markedly contracted tendon was lengthened with a modified gastrocnemius slide via an end-to-end approximation of the tendo-achilles. Prior to the anastomosis of the tendon all of the necrotic tendon, soft-tissue and scar formation was excised. Utilization of a medial/ lateral Krakow stitch closure was used to join the proximal and distal tendon. Since no remnants of a paratenon or glide mechanism remained in the area of closure, a decision was made to use amniotic membrane tissue to reduce the potential for adhesion formation after closure between the repaired tendon and soft tissues. The amniotic membrane was placed

directly on the tendon on the posterior area of suspected tendon adhesion to the soft tissue (Fig 4). The material adheres by surface tension and quickly reconstitutes and rehydrates and obviates the need for suturing (Fig 5).

Fig. 4. Application of amniotic membrane to Achilles tendon following tendon repair.

Post-operatively the patient was placed into dry sterile dressings and a non-weight bearing above the knee cast for two weeks followed by a three-week below-the-knee cast. At the fifth week a cam walker, non-weight bearing was used for an additional 2 weeks. Physical therapy started at the seventh week to start the patient's ambulation and gradual increase in strengthening and range of motion exercises. The patient tolerated the procedure quite well without complaints of pain and to date his ambulation is proceeding well with good range of motion and strength.

DISCUSSION

Peritendonous adhesions are a contributor to poor outcomes in patients undergoing tendon surgery. Following tendon repair surgery, fibroblasts from surrounding tissues migrate into the wound during the healing process leading to the formation of scar tissue.[25] The formation of adhesions between the tendon and surrounding tissue reduce the ability of the repaired tendon to glide normally. This limits post-operative rehabilitation as a result of a reduction in range of motion and an increase in inflammatory pain.

Amniotic membrane tissue has unique properties which may make it ideal for the prevention tendon adhesion to surrounding tissues. Unlike collagen-based dressings which are biological inert, amniotic membrane tissue has biologic properties which may be advantageous to its use for tendon repair surgery. This includes anti-fibrosis, anti-scarring, anti-inflammatory, and anti-microbial, properties in addition to low immunogenicity.[6]

Amniotic membrane reduces scar formation by down-regulating transforming growth factor (TGF)-β and its receptor expression on fibroblasts.[7,26] Since fibroblasts require TGF-β to be activated, this downregulation results in a reduction in fibroblast activity and fibrosis formation.

Fig 5. Achilles tendon wrapped with amniotic membrane prior to closing wound.

Amniotic membrane tissue has been shown to have anti-microbial properties as a result of its ability to produce β-defensins.[14] β-defensins are anti-microbial peptides which specifically help epithelial surfaces resist microbial colonization.[27,28] Amniotic membrane tissue also produces secretory leukocyte proteinase inhibitor (SLPI) and elafin.[14,29] In addition to their anti-inflammatory properties, elafin and SLPI both have antimicrobial actions and act as components of the immune system to provide protection from infection.[30] Amniotic membrane tissue has anti-inflammatory properties as a result of its ability to markedly suppress

the expression of the potent the pro-inflammatory cytokines, IL-1α and IL-1β.[11]

The commercially available amniotic membrane tissue product we used for these cases is processed following donation by birth mothers after cesarean section. Procurement and processing of the amniotic membrane is done in accordance with guidelines established by the U.S. Food and Drug Administration (FDA) and the American Association of Tissue Banks (AATB). All tissue recovered meets stringent specifications during donor screening and laboratory testing to reduce the risk of transmitting infectious disease.

CONCLUSION

Based on our initial clinical experience we believe that amniotic membrane tissues may be beneficial when used as a tendon wrap during tendon repair surgery. The demonstrated anti-adhesive, anti-inflammatory and anti-microbial properties of amniotic membrane tissue make this a potentially unique alternative to biologically inert collagen matrix products currently available for use in foot and ankle surgery and possible for tendon repair surgery of the upper extremities. As supplied, the product is easy to apply and does not require a change in surgical technique to use. Controlled clinical studies are needed to further document the benefits of amniotic membrane tissue for tendon repair surgery.

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