ARTIGO
DE REVISÃO

Ankle ligament injuries

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ABSTRACT

Acute ankle ligament sprains are common injuries. The majority of these occur during athletic participation in the 15 to 35 year age range. Despite the frequency of the injury, diagnostic and treatment protocols have varied greatly.

Lateral ligament complex injuries are by far the most common of the ankle sprains. Lateral ligament injuries typically occur during plantar flexion and inversion, which is the position of maximum stress on the anterotalofibular liagment (ATFL). For this reason, the ATFL is the most commonly torn ligament during an inversion injury. In more severe inversion injuries the calcaneofibular (CFL), posterotalofibular (PTFL) and subtalar ligament can also be injured.

Most acute lateral ankle ligament injuries recover quickly with nonoperative management. The treatment program, called "functional treatment," includes application of the RICE principle (rest, ice, compression, and elevation) immediately after the injury, a short period of immobilization and protection with an elastic or inelastic tape or bandage, and early motion exercises followed by early weight bearing and neuromuscular ankle training. Proprioceptive training with a tilt board is commenced as soon as possible, usually after 3 to 4 weeks. The purpose is to improve the balance and neuromuscular control of the ankle.

Sequelae after ankle ligament injuries are very common. As much as 10% to 30% of patients with a lateral ligament injury may have chronic symptoms. Symptoms usually include persistent synovitis or tendinitis, ankle stiffness, swelling, and pain, muscle weakness, and frequent giving-way.

A well designed physical therapy program with peroneal strengthening and proprioceptive training, along with bracing and/or taping can alleviate instability problems in most patients. For cases of chronic instability that are refractory to bracing and external support, surgical treatment can be explored. If the chronic instability is associated with subtalar instability that is refractory to conservative measures and bracing as outlined above, surgical treatment must address the subtalar joint as well.

Subtalar ligament injury and instability are probably more common than appreciated. Definition and diagnosis of this entity are difficult, however. Fortunately, it appears that in the majority of the acute injuries healing occurs with the same functional rehabilitation program as that for lateral ankle ligament sprains.

For chronic subtalar instability an intial attempt at functional rehabilitation with ankle proprioceptive training and bracing should be attempted. If this program fails primary repair or reconstruction can be beneficial. Reconstructive procedures must address the subtalar joint.

Subtalar instability often occurs in conjunction with talocrural instability, so careful diagnosis is critical in anyone with chronic ankle instability. If either is not addressed, the patient will continue to have problems.

Deltoid ligament injuries most often occur in association with ankle fractures. They are rare as isolated injuries. If no fracture is evident on radiographs, particular attention must be paid to the syndesmosis to ensure there is not an associated syndesmosis disruption. True isolated deltoid injuries seem to do well with non-operative functional treatment as for lateral ankle ligament injuries. Deltoid ruptures associated with ankle fractures appear to heal well by addressing the other injuries and allowing the deltoid to heal on its own. It is vital to correct any syndesmosis injury and to obtain correct bony alignment.

Syndesmosis injuries can be debilitating if not treated properly. Careful physical exam and interpretation of radiographs is necessary to obtain a correct diagnosis. Partial injuries appear to do well with functional rehabilitation. However, complete tears, if widening is not corrected, can lead to chronic ankle pain and early degenerative changes. Widening of the syndesmosis with a tear of the inferior tibiofibular ligaments is an indication for surgery to place a syndesmosis screw for reduction of the mortise. Protected weight bearing is required for about 6 weeks after surgery, at which time the screw should be removed. A functional rehabilitation program can then begin.

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LATERAL ANKLE LIGAMENT SPRAINS AND INSTABILITY

It is estimated that one inversion injury of the ankle occurs per 10,000 persons per day[1-3]. This means that approximately 5,000 and 23,000 of these injuries occur in the United Kingdom and United States, respecitvely, each day. Ankle sprains constitute 7% to 10% of all cases admitted to emergency departments of hospitals[4].

An ankle sprain is the most common injury in sports[5,6]. In a 1-year study, Maehlum[7], in Oslo, found that 16% of sports injuries were acute ankle sprains. In Sweden, Axelsson *et al.*[8] found that 14% of the sports injuries treated at the emergency ward of a central hospital were acute ankle sprains. Most ankle sprains occur in persons under 35 years of age[9].

Biomechanics

In the neutral position the bony anatomy of the ankle joint is responsible for stability. The osseous stability is enhanced by compressive loads in the weight-bearing position. Stormont *et al.*[10] showed that under loading the articular surface provided 30% of the rotational stability and 100% of the inversion stability. Under non-weightbearing conditions more restraint was provided by the ligamentous structures. With increasing plantar flexion, the osseous constraints are lessened, and the soft tissues are more susceptible to injury. The main lateral soft tissue stabilizers of the ankle are the ligaments of the lateral ligamentous complex: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL).

The ATFL is really nothing more than a thickening of the tibiotalar capsule that originates from the anterior border and tip of the lateral malleolus and runs anterior to insert on the neck of the talus. It is 6 to 10 mm wide, 20 mm long, and 2 mm thick[11]. It runs almost parallel to the axis of the neutral foot. When the foot is in plantar flexion, however, the ligament courses parallel to the axis of the leg[12,13]. Because most sprains occur when the foot is in plantar flexion, this ligament is most frequently injured in inversion sprains.

The CFL originates from the tip of the lateral malleolus and runs, with a slight backward inclination, to the lateral side of the calcaneus[14]. The ligament is extra-articular and lies just under the peroneal tendons. It is 20 to 25 mm in length with a diameter of 6 to 8 mm. Since this ligament runs more perpendicular to the axis of the neutral foot, isolated tears are less common with typical plantar flexion injuries. It is most commonly torn during moderately severe sprains where the ATFL tears and the injury continues around the outside of the ankle to also tear the CFL. Isolated injuries can occur but are infrequent and occur when the ligament is under maximum strain with the foot in dorsiflexion.

The PTFL arises from the posteromedial aspect of the lateral malleolus and runs posteromedially to the posterior process of the talus. It has an average diameter of 6 mm. The ligament is under most strain when the foot is in dorsiflexion. Isolated injuries of the PTFL are extremely rare. Most injuries occur as a result of very severe ankle sprains where the both the ATFL and CFL have been ruptured prior to tearing of the PTFL as the injury continues around the lateral aspect of the ankle.

The ATFL and PTFL restrict anterior and posterior displacement, respectively, of the talus with respect to the fibula and tibia. The CFL restrains inversion of the calcaneus with respect to the fibula[15,16]. During an inversion injury, the ATFL is the first ligament to be injured. If the tearing force continues, the CFL will be injured next, followed by the PTFL[11,17,18]. Brostrom found that isolated, complete rupture of the ATFL was present in 65% of all ankle sprains. A combination injury involving the ATFL and the CFL occurred in 20% of his patients.

Diagnosis

The most common presenting history is an athlete who “rolled” over the outside of his/her ankle. Most commonly this occurs when the foot is in plantar flexion at the time of the injury. The patient usually experiences pain localized to the lateral side of the ankle. The area of maximal tenderness and swelling usually indicates which ligament has been disrupted. This area is most frequently over the ATFL, especially on its fibular insertion. If the patient is not seen until several hours after the injury, generalized swelling and pain make the evaluation more difficult and unreliable. Most patients experience pain and discomfort when trying to bear weight on the injured extremity. After 24 to 48 hours, the lateral side of the injured ankle is usually discolored, appearing blue and yellow due to the hematoma organization and resorption. The discoloration is often located more distally than the injury itself because of the pooling affect of gravity. It is important that the entire ankle and foot are examined to be sure no other injuries have occurred.

Clinical stability tests for ligamentous disruption are performed. The anterior drawer test is used to asses the integrity of the ATFL and the inversion tilt test is used to assess both the ATFL and the CFL. These tests are difficult to interpret and often vary greatly between examiners, so caution must be exercised in their utility[19,20]. However, a positive test can help to confirm a suspicious history[11,21,22]. The tests are best performed betweeen 4 and 7 days after the injury. At that time the swelling, pain and tenderness are diminshed and the patient is able to relax during the exam. This lessens the amount of muscle spasm and guarding by the patient and increases the sensitivity of the exam.

The anterior drawer test is performed with the patient sitting with the knee flexed to relax the calf muscles. The heel is grasped firmly in one hand and the foot is pulled forward while pushing posteriorly on the anterior aspect of the distal tibia with the other hand. With a positive sign the examiner can see a sulcus anteriorly and medially over the anterior ankle joint. This indicates a tear of the ATFL. The amount of pathologic anterior laxity is recorded as mild, moderate, or marked. This is a subjective analysis by the examiner and agreement between observers is variable. The inversion tilt test is performed with the ankle in the neutral position. The heel is held stable while an attempt is made to invert the talus and calcaneus on the tibia. If the ATFL and CFL are disrupted the ankle will demonstrate increased inversion as compared to the normal ankle. If viewed on stress radiographs, the articular surfaces of the tibia and talus will separate, forming an angle that is referred to as the talar tilt. As in the anterior drawer test, the examiner should try to classify the pathology as mild, moderate, or marked instability. Comparison with the opposite side should always be done. As in the anterior drawer examination, criteria for ligament tears in the inversion tilt test are difficult to interpret, but as a general rule, more than 10 degrees greater than the normal side is pathologic.

The Ottawa Ankle Rules (OAR) have been developed and verified as a predictor of those patients with ankle sprains that should have x-rays. The OAR state that x-rays are only required for those patients with 1) tenderness at the posterior edge or tip of the medial or lateral malleolus, 2) inability to bear weight (four steps) either immediately after the injury or in the emergency room, or 3) pain at the base of the fifth metatarsal. With these criteria the number of unecessary x-rays is significantly reduced, while still maintaining a nearly 100% sensitivity for fractures. Standard x-rays, if necessary, should include routine anteroposterior (AP) and lateral views as well as an anteroposterior view with the foot in 15 to 20 degrees of internal rotation (mortise view). In this position it is possible to exclude distal tibial, fibular, and talar fractures because the lateral malleolus does not overlap the tibia and the talus is equidistant from both malleoli.

Stress radiographs are generally not indicated in the acute ankle sprain, because they will not change the treatment protocol. Stress radiographs are more often used for research purposes and they can be more useful for diagnosis and treatment of chronic ankle instabílity to differentiate between mechanical and functional instability, and to evaluate for subtalar instability. There is general agreement that the anterior drawer stress radiograph is more sensitive for ATFL insufficiency and that the talar tilt stress radiograph is more sensitive for CFL integrity. However, the amount of displacement that represents pathologic conditions is variable. The most commonly used criteria for the anterior drawer stress test is that of Karlsson[23], who defines abnormal laxity as an absolute anterior displacement of 10 mm, or a side to side difference of over 3 mm. What constitutes abnormal talar tilt is even more controversial. This is due to the large variation in "normal" talar tilt, which is reported from 0 to 27 degrees[23-25]. As a general rule more than 10 degrees greater than the normal side is considered pathologic.

Grading lateral ankle ligament sprains

Traditionally, ankle sprains have been classified in clinical practice as grade I (mild), grade II (moderate), and grade III (severe) injuries[12,13]. Grade I injuries involve ligament stretch without macroscopic tearing, little swelling or tenderness, minimal or no functional loss, and no mechanical joint instability. A grade II injury is a partial macroscopic ligament tear with moderate pain, swelling, and tenderness over the involved structures. There is some loss of joint motion and mild to moderate joint instability. A grade III injury is a complete ligament rupture with marked swelling, hemorrhage, and tenderness. There is loss of function and marked abnormal joint motion and instability. Grading of ankle sprains, however, remains a largely subjective interpretation of the abnormal laxity observed in the ankle and agreement between independent observers is variable.

Treatment and rehabilitation

Treatment of acute lateral ankle ligament injuries, in all cases, can proceed with non-operative measures[5,12-14,26]. The treatment program, called "functional treatment", includes application of the RICE principle (rest, ice, compression, and elevation) immediately after the injury, a short period of immobilization and protection with an elastic or inelastic tape or bandage, and early motion exercises followed by early weight bearing and neuromuscular ankle training. Proprioceptive training with a tilt board is commenced as soon as possible, usually after 3 to 4 weeks. The purpose is to improve the balance and neuromuscular control of the ankle. The efficacy of tilt board training has been shown in prospective, randomized studies[27,28] with the maximum effect of tilt board training occuring at about 10 weeks. Additional mobility and muscle exercises, especially peroneus muscle strengthening, are recommended. Using this type of regimen, Jackson *et al.*[29] found that in West Point cadets the period of disability was only 8 days in patients with grade I injuries and 15 days in those with grade II injuries. Even for grade III injuries, functional rehabilitation has been shown to provide the quickest recovery in ankle mobility and the earliest return to work and physical activity without compromising the late mechanical stability of the ankle[30-32]. In addition, functional treatment is free of complications, whereas surgical treatment has some serious complications, though infrequently. Functional treatment produces no more late symptoms (giving way, pain, swelling, stiffness, or muscle weakness) than surgical repair and cast, or than cast alone. Furthermore, secondary surgical repair of the ruptured ankle ligaments (delayed anatomic repair) can be performed even years after the injury if necessary, with good results that are comparable to those achieved with primary repair[18,33-36].

The functional treatment protocol is based on the biological healing process. The initial treatment is directed toward avoiding excess swelling and injury, so the tissue is ready for the healing process to begin. During the first one to three weeks, the tissue responds with vascular ingrowth, fibroblast proliferation and new collagen formation. Protection from inversion is necessary during this phase of healing to prevent excess formation of weaker type III collagen formation that can contribute to chronic elongation of the ligament. At about three weeks after the injury the collagen tissue starts to mature. During this phase, controlled stress on the ligament will promote proper collagen fiber orientation. In addition, motion, stretching and strengthening will avoid the harmful affects of immobilization on the muscle, joint cartilage and bone. As the ligament heals the collagen matrix will continue to mature so that full return to activities will be possible between four and eight weeks after the injury.

In addition to functional therapy other therapeutic modalities have been advocated to speed recovery. The most frequently used are ultrasound, temperature-contrast baths, short waves, and various current therapies such as diadynamic or interference current therapy and electrogalvanic stimulation. Randomized controlled studies, however, have not shown effectiveness of these therapies[37,38]. Of these different types of passive physical therapy, only cryotherapy has been proved to provide any benefit[39-41].

The efficacy of nonsteroidal anti-inflammatory drugs (NSAIDS) in the treatment of acutely sprained ankles has been studied in prospective, randomized double-blind trials[2,4,42]. NSAID treatment has been found to be more effective than placebo in limiting short term pain and disability, although the differences are not striking. Electrical muscle stimulation (EMS) may be useful in preventing calf muscle wasting and improving muscle coordination and range of motion of the joint. But no studies have been done to prove its effectiveness.

After an ankle sprain we allow an athlete to return to sports participation when he/she has full ankle range of motion, has 90% strength in the injured ankle as compared to the healthy side, and can run and cut at maximum speed without pain.

Chronic lateral ankle ligament instability

Persistent problems after ankle ligament injuries are not uncommon. After either conservative or operative treatment, 10% to 30% of patients with a lateral ligament injury may have chronic symptoms. In patients with persistent problems or unusual symptoms, other problems must be considered, such as stress fractures (particularly the Jone’s fracture), osteochondral fractures, osteochondritis dissecans, midfoot sprains, and peroneal tendonitis or subluxation.

Symptoms usually include persistent synovitis or tendinitis, ankle stiffness, swelling, and pain, muscle weakness, and frequent giving-way[43]. Many of these problems are associated with ankle instability. It is important to differentiate between the two types of ankle instability-mechanical and functional. Mechanical instabiltiy refers to abnormal laxity of the ligamentous restraints, and functional instability refers to normal ligamentous restraint but abnormal function, with recurrent giving way episodes. Mechanical instability alone is of minimal clinical importance. But, often mechanical and functional instability occur together. It is also important to consider the subtalar joint as part of the cause of the instability. If subtalar instability is present, the subtalar ligaments must be considered as well.

A physical therapy program with peroneal strengthening and proprioceptive training should initially be instituted. Bracing and/or taping should be used as adjunctive treatment to help alleviate instability problems. The exact mechanism of the effect of bracing is not well understood, but most patients experience some benefit. There are two main theories for their effectiveness: mechanical support, and increased neural and proprioceptive feedback[14].

In cases of chronic instability that are refractory to bracing and external support, surgical treatment can be beneficial. Many surgical procedures have been described[18,33,35,44-49]. “Anatomic reconstruction” (shortening and reinserting the ligaments) of the lateral ligaments seems to be the easiest and most effective of these[50]. Postoperatively, we immobilize the ankle in a below-the-knee cast for 7 to 10 days. One to six weeks postoperatively we use a walking boot that allows motion of 0 to 20 degrees. After about 3 weeks postooperatively, plantar and dorsiflexion exercises are begun, passively at first, and then progressing to active range of motion. Muscular and proprioceptive training are begun at about 6 weeks after the surgey.

For cases with associated subtalar instability that are refractory to conservative measures and bracing as outlined above, surgical treatment must address the subtalar joint as well. This can be addressed by various reconstructions or by direct primary repair. Results of surgical treatment are difficult to evaluate since there is no agreement on what constitutes subtalar instablity.

In cases of instability treated by surgery, sports activities are allowed approximately 3 months after surgery. An ankle brace may be needed during sporting activities for 6 to 8 months postoperatively. The results of anatomic reconstructions have been impressive[18,33-35,51,52].

SUBTALAR SPRAINS AND INSTABILITY

Biomechanics

The inferior articulations of the talus are through the talocalcaneal and talonavicular joints. The talocalcaneal joint has distinct articulations that are separated by the sinus tarsi. The talonavicular joint is formed by the talar head and its articulation to the spring ligament and the articular surface of the navicular. The important structures that contribute to stability of the subtalar joint are the calcaneofibular (CFL), the lateral talocalcaneal ligament, the cervical ligament, the interosseous talocalcaneal ligament, and a portion of the inferior extensor retinaculum[53].

The subtalar joint moves in a screwlike fashion about an axis of rotation that forms an angle of 10 to 15 degrees with the sagittal plane and an angle of 45 degrees with the horizontal plane of the foot[54,55]. The main function of the subtalar joint is to allow the foot to conform to the ground during walking on uneven surfaces. The range of talocalcaneonavicular motion has been estimated to be 24 degrees[56], but average motion during the stance phase of walking is only about 6 degrees[57].

Diagnosis

Subtalar sprains are difficult to define, and are even more difficult to identify. The incidence of these injuries, therefore, is unknown, and it is probably more common than appreciated. Injuries to the subtalar ligaments most often occur in conjunction with injuries of the lateral ligaments of the ankle. In one study by Meyer *et al.*[58], 40 patients with acute ankle sprains underwent subtalar arthrograms. Of the 40 patients, 17 (43%) had contrast leaks into the sinus tarsi, indicating possible subtalar ligament injury. But the incidence of chronic ankle instability does not appear to be as high. One study estimated that subtalar instabilility is present in about 10% of patients who have lateral ankle ligament instability[55]. So it would appear that most of the acute subtalar sprains will do well with functional treatment, as for an acute lateral ankle ligament sprain. This has not been scientifically verified, however, and the difficulty in showing this is formidable, since definition and diagnosis of subtalar sprains are not agreed upon in the literature.

Since most of the subtalar sprains occur in combination with lateral ligament injuries of the ankle, acute symptoms of subtalar sprains are similar to, and can be masked by lateral ankle ligament sprains. Injury to the subtalar joint can be suspected if there is tenderness over the lateral aspect of the subtalar joint, but this can be difficult to differentiate from the tibiotalar joint because of the close proximity and the swelling that will obscure the anatomy.

Clinical evaluation of subtalar instability is very difficult and unreliable. An evaluation of the change in angle between the heel and the tibia with passive inversion and eversion of the heel can be made by comparing this angle to that on the uninjured side[55], but the sensitivity and specificity of this test are unknown.

Routine AP, lateral, and mortise view radiographs should be taken to rule out fractures. In addition, stress radiographs (anterior drawer and inversion stress tests) can sometimes be beneficial in evaluating the lateral ligaments of the ankle.

If a major sprain of the subtalar joint is suspected, subtalar stress radiographs[59], subtalar arthrography[58], or stress tomography[55] can show increased motion. However, these findings are not uncommon in people without symptoms, so interpretation of the studies is unclear. The use of these special examinations depends on the policy of treatment chosen for these injuries. If treatment is non-operative, stress radiographs are not needed because the results will have no effect on the treatment. If surgery is considered, stress radiographs may be helpful in planning the surgery.

Classification of subtalar sprains

Acute spains of the subtalar joint can be classified by the injury mechanism and the degree of ligamentous damage[58]. The injury can occur with the foot in either plantar-flexion or dorsi-flexion. Forceful supination with the foot in plantar-flexion will first cause injury to the anterior talofibular ligament (and possibly the cervical ligament), followed by either disruption of the calcaneofibular ligament and lateral capsule (type 1) or tearing of the interosseous talocalcaneal ligament (type 2). When the ankle is in dorsi-flexion, rupture of the calcaneofibular ligament, cervical ligament, and interosseous talocalcaneal ligament (type 3) occur, but the anterior talofibular ligament remains intact because it is not under tension with the ankle in dorsi-flexion. A type 4 subtalar sprain is rupture of all lateral and medial capsuloligamentous components of the posterior tarsus in association with a subtalar sprain. This injury is probably produced by forceful supination of the hindfoot with an initially dorsiflexed ankle that swings into plantar flexion[58].

Treatment and rehabilitation

Acute surgical repair of subtalar ligament injuries must be considered scientifically unproven and rarely indicated. This is especially true for patients with partial tears of the ligaments with no or only mild subtalar instability. In these cases a functional rehabilitation program is recommended. The program is the same as that used for lateral ankle ligament injuries as described in detail in the previous section. Briefly, this includes an initial program to reduce swelling and prevent further injury, followed by early range of motion exercises and finally, weight bearing and neuromuscular ankle training[30]. For partial tears and mild injuries the patient’s disability time can be limited to 2 to 3 weeks.

Treatment of severe subtalar ligament injuries can also proceed by non-operative means with a short period of immobilization followed by a functional rehabilitation program. There is, however, a higher incidence of chronic instability with the higher grade injury. Because of this, for severe injuries, at least one author has recommended acute repair of both the lateral ankle ligament structures and subtalar ligaments to prevent chronic instabilty[58].

Chronic subtalar instability

Subtalar instability is difficult to separate from lateral ankle ligament instability, and in fact the problems may coexist. The symtoms of both are chronic "giving way" episodes of the ankle during activity, with a history of recurrent sprains, and/or pain, swelling, and stiffness. Tenderness over the subtalar joint can help to implicate involvement of the subtalar ligaments, but this is not very sensitive or specific. The best way to try to differentiate talocrural from subatalar instability is by stress radiographs, but this can also be difficult because of the large overlap of normal values.

In patients suspected of having chronic ankle and subtalar instability, delayed anatomic repair (shortening and reinsertion) of the ligaments has been shown to give good results[34,51]. If a reconstructive procedure is considered, the only procedure that addresses both the anterior talofibular and the calcaneofibular ligaments is the Chrisman-Snook reconstruction[45,60]. Because of this, the Chrisman-Snook procedure may provide better long-term results than other reconstructive procedures[61]. If surgery is indicated, we prefer repair of the talocrural and subtalar ligaments.

DELTOID LIGAMENT TEARS

Biomechanics

The deltoid ligament is composed of a fan-shaped, vertical superficial layer and a short and more horizontal deep layer[62]. The superficial part consists of the tibionavicular ligament anteriorly, the tibiocalcaneal ligament in the middle (originating 1 to 2 cm above the tip of the medial malleolus and inserting into the sustentaculum tali of the calcaneus), and the superficial tibiotalar ligament posteriorly. The horizontal deep layer of the deltoid ligament consists of the strong anterior and posterior tibiotalar ligaments. The deep layer is more important to ankle stability than the superficial layer[62]. During ankle motion, however, all parts of the deltoid ligament function as a unit, giving static support to the ankle during abduction, eversion, and pronation (eversion, external rotation, and abduction) of the foot. The tibiocalcaneal and tibionavicular ligaments give medial ligamentous stability to both the talocrural and subtalar joints, whereas the deep tibiotalar ligaments are responsible for the medial stability of the talocrural joint only.

Isolated injuries to the deltoid ligament are very rare. In Brostrom's[11] series of 281 acute ankle sprains only 3% of ankle ligament injuries were located on the medial side. Nearly all of the medial sided injuries were partial ligament tears. Complete deltoid ligament ruptures most often occur in combination with ankle fractures. In Harper's[63] review of 42 patients with complete deltoid ligament ruptures, all were associated with other injuries. Nearly all patients in this study had disruption of the syndesmosis ligaments with or without other associated injuries. In the ankle fracture classification described by Lauge-Hansen[64], a deltoid ligament or medial malleolar fracture occurs as the injury pattern continues around the ankle in a circular fashion. The three most characteristic mechanisms of injury of the deltoid ligament occur from pronation-abduction, pronation-external rotation, and supination-external rotation of the foot[64-66]. The first component describes the position of a planted foot, and the second term indicates the relative motion of the foot as the leg rotates about the planted foot. So, in the pronation-abduction injury, the foot is planted in pronation as the upper body falls to the lateral side of the foot placing a large abduction force onto the ankle and deltoid ligament. Since the forces required to injure the strong deltoid ligament are so great, the injury usually continues through the syndesmosis by the strong lever action of the lateral malleolus on the lateral aspect of the talus.

Diagnosis

In deltoid ligament injuries, pain, tenderness, and swelling are usually present on the medial side of the ankle. Ecchymosis may be present after 1 to 2 days. In a complete deltoid tear, there may be a palpable defect below the medial malleolus. The patient is usually unable to walk or bear weight on the injured leg. If a deltoid ligament injury is present, it is extremely important to evaluate the ankle for a syndesmosis sprain or fracture. Inspection and palpation of the bony and ligamentous structures will indicate which areas are injured. The proximal part of the fibula must also be examined to rule out complete syndesmosis disruption. Clinical stress tests of deltoid ligament disruption are usually not possible because of the associated syndesmosis injuries or fractures.

Radiographs are necessary to evaluate the bony structures and syndesmosis. The minimum requirement is for AP, lateral and mortise (an AP with the ankle in approximately 20 degrees of internal rotation) views. If there is any suspicion of a proximal fibular fracture, this should also be x-rayed. Deltoid ligament injuries are most easily seen on radiographs by measuring the width of the medial clear space on both the AP and mortise films. A distance of 4 mm or greater is abnormal and indicates a complete disruption of the deltoid ligament and syndesmosis; maximum medial joint space widening is 2 to 3 mm with an intact deltoid ligament[67,68]. One must keep in mind that in isolated deltoid ruptures the medial clear space will not widen because the lateral malleolus will hold the talus in position. Likewise, syndesmosis injuries without deltoid tears will not have medial clear space widening. In this case, the inferior tibiofibular joint must be carefully evaluated for syndesmosis injury. Radiographic eversion stress x-rays, arthrography, or MRI may be used in difficult cases, but they are rarely needed since the diagnosis is usually made by clinical exam and plain radiographs. And, for isolated deltoid injuries, treatment is by non-operative means and will not be affected by the studies.

Treatment and rehabilitation

Isolated deltoid ligament ruptures, which are usually located on the anterior aspect of the ligament, can be treated with a functional rehabilitation program and the prognosis is almost without exception excellent or good. Occasionally, however, deltoid tears can result in chronic pain and tenderness over the anteromedial aspect of the deltoid ligament. It is very rare to have an isolated complete tear of the deltoid. Most of these occur in conjunction with fractures and/or syndesmosis disruption. There is disagreement on how to manage complete deltoid ligament ruptures in this setting. Many authors recommend operative repair of the deltoid ligament at the time of stabilization of accompanying fractures and/or stabilization of sydesmosis injuries[69]. The basis for this is to prevent other tissues from interposing between the torn ligament ends and thereby preventing healing. Hamilton[70] further supports an operative approach based on the fact that no satisfactory reconstructive procedure exists to correct chronic insufficiency of this structure. There are, however, several reports that surgical repair of the lateral structures and syndesmosis without repair of the deltoid ligament gives satisfactory results[63,71,72]. Harper[63] found that the deltoid ligament healed sufficiently without repair, provided that a good reduction of the medial joint space, syndesmosis, and lateral malleolus were obtained and, that reduction was maintained after surgery. No evidence of ligamentous instability or osteoarthritis was noted in his 36 patients who were followed for 1 year or longer. The key, therefore, seems to be exact anatomic reduction of the ankle mortise. As long as this can be done without direct repair of the deltoid ligament, the results appear to be satisfactory. These results have been verified by Stromsoe *et al.*[73].

Immediate postoperative treatment of the deltoid tears, sutured or not, depends on the condition of the accompanying fractures or syndesmosis sprain. In some patients who have a syndesmosis screw, full weight bearing may be prevented until the screw has been removed, usually 6 to 10 weeks postoperatively. Rehabilitation of these ankles follows strictly the guidelines given previously in the section on lateral ligamentous injuries of the ankle.

The criteria for return to sports after a subtalar sprain are similar to those after a lateral ligamentous sprain of the talocrural joint. In the case of subtalar sprain, however, it should be remembered that the return to activity may be two to three times longer than in the case of a “simple” lateral ligamentous sprain of the talocrural joint. Also, residual mechanical instability is often more frequent in subtalar sprains.

Chronic medial instability of the ankle

Complete isolated deltoid ligament rupture is possible, but it is extremely rare. Moreover, medial instability of the ankle cannot exist as an isolated entity[70]. Any widening of the medial clear space suggesting deltoid insufficiency must be associated with syndesmosis diastases or a displaced fracture of the fibula[70]. Therefore, chronic medial instability of the ankle is always a result of a poor primary reduction and fixation of the other structures, in addition to insufficiency of the deltoid ligament. The best treatment for chronic medial instability is to prevent it by obtaining a good primary reduction of all damaged structures. Late reconstructions of the deltoid ligament or the syndesmosis often give unsatisfactory results.

TIBIOFIBULAR SYNDESMOSIS TEARS – “HIGH ANKLE SPRAINS”

Biomechanics

The tibiofibular syndesmosis is the structure that maintains the relationship between the distal tibia and the fibula. The syndesmosis consists of the anterior and posterior inferior tibiofibular ligaments and the interosseous membrane. The anterior and posterior tibiofibular ligaments are attached superiorly and medially to the tibia and inferiorly and laterally to the fibula[62]. The most distal fascicle of the posterior inferior tibiofibular ligament has been named the transverse tibiofibular ligament[74].

There is a small groove on the distal tibia in which the fibula rotates about its vertical axis during dorsal and plantar flexion of the ankle. The anterior and posterior inferior tibiofibular ligaments are responsible for holding the fibula in the groove. The interosseous membrane blends into the anterior and posterior tibiofibular ligaments at about 1 to 2.5 cm above the dome of the talus[75]. From there it continues superiorly, connecting the adjacent rough surfaces of the tibia and fibula. The anterior inferior tibiofibular ligament controls external rotation and posterior displacement of the fibula with respect to the tibia, but all three tibiofibular ligamentous structures prevent excessive lateral displacement of the fibula. Lateral displacement of the fibula will cause widening of the ankle mortise.

Diastasis of the syndesmosis occurs with partial or complete rupture of the syndesmosis ligament complex[76]. Isolated complete syndesmosis injuries are rare, and there is relatively little information in the literature about ankle diastasis in the absence of fracture. Fritschy[77] reported only 12 cases of isolated syndesmosis rupture in a series of more than 400 ankle ligament ruptures. Several of these injuries occurred in world-class slalom skiers during a slalom race in which they straddled a gate. In all of them the rupture occurred when a sudden external rotation of the ankle caused the talus to press against the fibula, thus opening the distal tibiofibular articulation.

Partial tears of the anterior inferior tibiofibular ligament, however, are not uncommon. Like the isolated ruptures above, they most commonly occur from a violent external rotation of the foot while the ankle is in dorsiflexion. Though isolated partial syndesmosis injuries do occur with some frequency, it is much more common for the injury to be associated with a fracture and/or deltoid ligament injury. The frequency of syndesmosis ruptures is directly related to the type and level of associated fibular fractures. If the fibular fracture is a transverse avulsion at or below the level of the ankle joint (type A fracture in Weber's classification), syndesmosis ligament injury or avulsion fracture occurs very seldom. If the fibular fracture is spiral beginning at the level of the syndesmosis (Weber's type B), syndesmosis rupture or avulsion fracture is present in approximately 50% of cases. Finally, if the fibular fracture occurs anywhere between the syndesmosis and the proximal head of the fibula (Weber's type C), the syndesmosis rupture or avulsion fracture occurs in the majority of cases[65,74]. This is predicted by the Lauge-Hansen injury mechanism classification of ankle fractures. In this classification scheme, ligamentous injuries or fractures occur as the injury pattern continues around the ankle in a circular fashion. The most characteristic mechanism of injury of the syndesmosis occurs from pronation-external rotation of the foot[66]. The first component describes the position of a planted foot, and the second term indicates the relative motion of the foot as the leg rotates about the planted foot. So, in the pronation-external rotation injury, the foot is planted in pronation as the upper body rotates and causes a relative external rotation of the foot. This places large forces first onto the deltoid ligament, then to the anterior inferior tibiofibular ligament, the fibular shaft above the syndesmosis, and finally to the posterior inferior tibiofibular ligament. Since the forces required to completely rupture the strong deltoid ligament are so great, the injury usually continues through the syndesmosis by the strong lever action of the lateral malleolus on the lateral aspect of the talus.

Diagnosis

An isolated syndesmosis tear can be very difficult to detect. Pain and tenderness are located primarily on the anterior aspect of the syndesmosis and interosseous membrane. The patient often will be unable to bear weight on the injured ankle. Active and passive external rotation of the foot will be painful. The best way to test the syndesmosis is by external rotation of the foot with the ankle in dorsiflexion, the so-called external rotation test. This stresses the syndesmosis by levering the talus against the lateral malleolus. In a syndesmosis injury pain will occur over the anterior inferior tibiofibular ligament and joint. The squeeze test may also cause pain. This test is performed by compressing the tibia and fibula together above the midpoint of the calf. If a syndesmosis injury is present the patient will have pain at the inferior tibiofibular joint.

Routine AP, lateral, and mortise view radiographs are needed to exclude fractures, osseous avulsions, and to evaluate the syndesmosis for widening. Acceptable radiographic parameters that indicate syndesmosis diastasis are controversial. And measurements can be affected greatly by the amount of rotation of the leg. The most commonly used parameters are a joint space widening of greater than 5 mm, or a tibiofibular overlap of less than 10 mm, both as measured on the AP view. However, a recent study[78] has indicated that normal subjects display a fair amount of variability in absolute measurements, but the ratio of measurements to the fibular width was more consistent. Ninety percent predictive intervals for a normal relationship were: a tibiofibular overlap to fibular width ratio greater than 24%, and a tibiofibular clear space to fibular width ratio of less than 44%, both as measured on the AP radiograph. Stress radiographs in external rotation, in both dorsiflexion and plantar flexion, may display the diastases but their utility is questionable[77]. Recent studies have advocated the use of MRI for evaluating the syndesmosis[79]. This has now become the test of choice for difficult cases.

Treatment and rehabilitation

Partial syndesmosis tears usually involve the anterior tibiofibular ligament and do not have widening of the distal tibiofibular joint space. These injuries are treated non-operatively with functional treatment as described in the section on acute lateral ankle ligament sprains. These "high ankle sprains" usually take longer to resolve than the more common lateral ankle ligament sprain. This may be several weeks or months until symptoms allow for sports participation.

Isolated complete syndesmosis tears do occur, but they are relatively rare. However, untreated complete syndesmosis injury or tibiofibular diastases are a potentially serious injury that usually results in long term disability. If the whole syndesmosis is ruptured, the fibula can shorten and rotate externally, leading to joint incongruency and subsequent arthritic changes[70]. So, a correct diagnosis and treatment is essential. A complete tear is a clear indication for surgical intervention[80] with placement of a temporary syndesmosis screw to stablilize the joint. During the syndesmosis screw fixation, the ankle should be held in 30 degrees of dorsiflexion, since at that position the widest part of the talus is engaged in the ankle mortise and this will not overconstrain the joint. The screw should be placed about 1 to 2 cm proximal to the tibiofibular ligaments, and directed anteromedially and perpendicular to the joint[81].

Syndesmosis injuries are more commonly associated with malleolar fractures and/or deltoid ligament tears. In this case, the other injuries should be addressed first, and the syndesmosis must then be stabilized as above. It is important that the fracture of the fibula be accurately reduced and brought out to full length. This is usually best accomplished by stabilizing the fracture with a semitubular or one third tubular plate and 3.5 mm cortical screws. One of the screws for the plate can sometimes be used to also stabilize the syndesmosis. If there is persistent medial widening greater than 2 mm on the mortise view, the medial joint space should be explored for invagination of soft tissue. Post-operatively a short leg cast is applied. In most cases the cast can be replaced by a walking boot at 2 to 4 weeks and range of motion exercises can begin. This is continued for the next 4 weeks. Partial weight bearing is generally allowed at about the same time. We recommend that the syndesmosis screw be removed after 6 to 8 weeks. Removal is usually easy to do under local anesthesia at an outpatient unit. Removal is recommended because the screw may become loose and sometimes break within the joint. At about 6 weeks full weight bearing is allowed and a rehabilitation program following the guidelines for normal ankle rehabilitation described previously in this chapter is begun. Return to sports is usually not possible until after 4 to 6 months.

CONCLUSIONS

Acute ankle sprains are common injuries in athletics and lost participation time from these injuries is significant. Fortunately, functional treatment has given good results in most cases, and lost participation time has been minimized.

The most disabling potential problem area is undetected and untreated syndesmosis injuries, with or without deltoid ligament injury. Care should be taken to carefully evaluate the syndesmosis in all ankle injuries. Potential late problems can develop from instability of the lateral ankle ligaments and/or subtalar ligaments. The majority of these can be treated well with functional and proprioceptive training with external bracing or taping, or with delayed surgical repair in refractory cases.

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