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Acute ankle injury and chronic lateral instability in the athlete

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Acute ankle injuries

Ankle sprains are the most common injuries in sports and recreational activity, accounting for 40% of all athletic injuries, especially in basketball, soccer, cross-country running, dance, and ballet [1]. Ankle injuries make up 10% of all visits to the emergency room [2]. Ankle sprains account for 53% of injuries in basketball players and 29% of all extremity injuries in soccer players, and account for the most common trauma in modern dance and classical ballet [3,4]. In football, approximately 12% of all time lost to injuries is secondary to ankle injuries [5]. Three quarters of ankle sprains involve the lateral ligament process. Within specific sporting activities, the incidence is equal for males and females [5].

Ankle ligament anatomy and biomechanics

Stability of the ankle depends on its passive or ligamentous supports as well as its muscular (peroneals) or active support. The ankle ligaments can be divided into three groups: lateral ligaments, medial ligaments, and the ligaments of the syndesmosis. The most common injuries involve the lateral ligaments.

The lateral ligamentous complex consists of the anterior talofibular (ATFL), calcaneofibular (CFL), posterior talofibular (PTFL), and lateral talocalcaneal (LTCL) ligaments. The PTFL and LTCL are less commonly injured during

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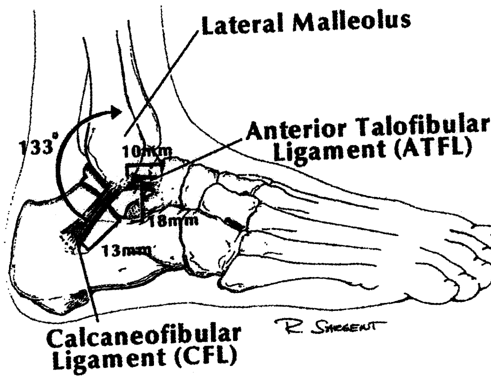

Fig. 1. Lateral ankle ligaments. Detailed anatomy depicting the orientation of the anterior talofibular and calcaneofibular ligaments. (*From* Baumhauer J, O'Brien T. Surgical considerations in the treatment of ankle instability. J Athl Train 2002:37(4)458–62; with permission.)

twisting injuries to the ankle and are of less clinical significance in chronic ankle instability. Anatomic variation in lateral ligament anatomy is common, but a general pattern is observed (Fig. 1).

The anterior talofibular ligament is a thicker portion of the anterior ankle joint capsule, measuring 6 mm to 10 mm in width, 10 mm in length, and 2 mm in thickness [6]. It is contiguous with the joint capsule and is not easily defined in patients with recurrent ligament injury. The ATFL is the weakest of the lateral ankle ligaments [7]. It originates about 1 cm proximal to the tip of the lateral malleolus, and then inserts into the lateral talus just beyond the articular surface, at about 18 mm proximal to the subtalar joint. With the ankle is neutral position, the ATFL forms an angle of approximately 75° degrees with the floor from its fibular origin. The role of the ATFL is as the primary restraint against plantar flexion and internal rotation of the foot [8].

The calcanealfibular ligament is an extra-articular rounded ligament that crosses both the tibiotalar and subtalar joints. Measuring 20 mm to 25 mm in length and with a diameter of 6 mm to 8 mm, it runs obliquely downwards and backward to attach to the lateral surface of the calcaneus about 13 mm distal to the subtalar joint. The angle between the CFL and the fibula with the ankle in neutral position averages 133°, but is variable, ranging from 113° to 150°. It is in close association with the peroneal sheath, acting as the floor of the sheath. For this reason, a CFL injury is usually associated with a rupture of the peroneal sheath and occasionally a tear of the peroneal tendons and or of the peroneal retinaculum. The angle between the CFL and the ATFL is approximately 104°, and this angle is an important detail during reconstructive procedures. From a relaxed position with the foot in neutral position, the CFL becomes more taut as the foot is brought into dorsiflexion. The CFL is the second weakest of the lateral ligaments.

Mechanism of injury

The most common mechanism of injury to the lateral ankle ligaments occurs from a forced plantar flexion and inversion of the ankle, as the body's center of gravity rolls over the ankle. First, the ATFL is injured, followed by the CFL. According to Attarian et al, the maximum load to failure for the CFL was 2 to 3.5 times greater than that for the ATFL (345.7 versus 139 newtons) [9]. Brostrom surgically explored 105 sprained ankles and found that two thirds of the cases had an isolated ATFL tear [10]. In this same study, the second most common injury was a combined rupture of the ATFL and CFL, which occurred in 25% of the cases.

Medial or deltoid ligament tear is not as common, but does occur during an eversion injury when the body's center of gravity rolls over the everted foot. The anterior portion of the deltoid ligament is most commonly injured. Most deltoid injuries are not isolated but do occur in conjunction with a fracture of the lateral malleolus [11].

High ankle sprains—isolated syndesmosis injuries—are uncommon. Fritschy reported only 12 cases of isolated syndesmosis rupture in a series of more than 400 ankle ligament ruptures [12]. These injuries are caused by a combination of forced external rotation, dorsiflexion, and axial loading of the ankle.

Diagnosis

A careful history and physical can determine the severity of the injury and isolate the injured structures. For the first few days, an examination may be difficult to perform because of the acute pain and swelling that accompanies the injury. Van Dijk's 1994 thesis in argues that the clinical examination has the greatest reliability and specificity 4 to 7 days after the injury [13].

History

Most patients describe a rolling over of the ankle with an inversion, plantar flexion, or internal rotation mechanism. The major complaint is acute lateral ankle pain following an inversion injury to the ankle that is usually accompanied by a snap. Patients typically are seen early after injury in an emergency department or urgent care setting. They then present to the specialist within a week for further evaluation and treatment. Extent of ligament injury is related to information about initial swelling, ability to bear weight, and later ecchymosis. In general, the more extensive the ligament injury, the more difficult it is to bear weight, the more swelling noted acutely, and the more ecchymosis that develops over a few days.

Physical examination

Although the pain during the first hours after injury is often localized to the injured area, it soon becomes diffuse during the first few days. After a few days, careful palpation will confirm which ligaments were most likely injured. In addition, a thorough examination is conducted to rule out other occult injuries. It is common for other injuries to be associated with an inversion injury to the lateral ligaments of the ankle. Most of the pain is usually localized over the area of the ATFL (the most commonly injured ligament) and is best evaluated 4 to 7 days after the injury; however, if the CFL is injured, most of the tenderness will be localized at the calcaneal insertion of the ligament. Funder et al in 1982 found that 52% of the patients with tenderness over the ATFL had a rupture of this ligament, and 72% of patients with tenderness over the CFL insertion had a rupture of the ligament [14]. The area of maximal swelling shows which ligament is disrupted—most frequently, the ATFL at its fibular insertion, followed by the CFL over its calcaneal insertion.

Diagnostic studies

Stiell and Greenberg's study in 1992 devised a set of clinical rules for the use of radiography in acute ankle injuries. These clinical guidelines for ordering ankle radiographs became known as the Ottawa ankle rules (OAR) [15]. These are listed in Box 1 below. Using the OAR has reduced cost in one emergency department by 3 million dollars per 100,000 patients, and the sensitivity for fractures remained nearly 100. When indicated, the radiographs should include anterior-posterior (AP), lateral, and mortise views. The mortise view is required to exclude distal fibular, tibial, and talar dome fracture, because the lateral malleolus is not overlapping the tibia, and the talus is equidistant from both malleoli. Stress radiographs are not usually indicated in an acute twisting ankle injury because they will not change the treatment protocol.

Ultrasonography has recently been advocated for the evaluation of acute ankle ligament injuries, but it has yet to be accepted as a proven imaging technique for this condition. CT and MRI are typically not indicated in the majority of twisting ankle injuries. In select cases of acute lateral ankle sprains, however, MRI may be beneficial, especially in those suspected of having associated injuries.

Differential diagnosis

With an inversion injury to the ankle, the most common structures injured are the lateral ankle ligaments; however, associated injuries are not uncommon and

Box 1. Ottawa ankle rules. Radiographs only if ankle pain and one of the following:

- Bone tenderness at the base of the fifth metatarsal
- Inability to bear weight immediately after the injury and for four steps in the emergency department
- Bone tenderness at the tip or posterior edge of either malleolus

Box 2. Acute lateral ankle ligament injury: potential associated pathology

Bony injuries: fractures of the ankle and foot

Lateral, medial, posterior malleolus
Proximal fibula
Posterolateral process talus
Lateral process talus
Anterior process calcaneus
Base of fifth metatarsal
Navicular or other midtarsal bones
Growth plate injuries in children (Salter Harris I distal fibula)

Osteochondral fractures

Anterolateral talus
Posteromedial talus
Distal tibia

Ligamentous injuries

Hindfoot sprain (calcaneocuboid, bifurcate, cervical, talocalcaneal)
Midfoot sprain (tarsal-metatarsal, Lisfranc ligament complex)

Tendon injury

Peroneal brevis tear (most common)
Peroneal longus tear
Peroneal retinaculum injury (subluxation/dislocation peroneal tendons)
Subluxation of dislocation of the peroneal
Medial ankle tendons (posterior tibial [PT], flexor digitorum longus [FDL], flexor hallucis longus [FHL])

Nerve injury

Superficial peroneal nerve

should be considered when evaluating patients with acute ankle injuries. Box 2 lists pathologies possibly associated with acute lateral ankle ligament injury. Frey et al [16] evaluated MRI findings in patients (15 cases) with acute lateral ankle sprains. High percentages of peroneal tendon pathology (brevis tear, 27%; longus tear, 13%; peroneal retinaculum injury, 27%) were noted. Surprisingly, medial tendon and deltoid ligament pathology were quite common after an acute inversion injury: deltoid ligament injury (6%), posterior tibialis tendonitis (53%), flexor hallucis tenosynovitis (13%), and flexor digitorum longus tenosynovitis (7%). Although the majority appear to resolve over time, persistent dysfunction may result if associated injuries are not properly diagnosed and treated in the acute setting.

Grades of acute ankle injury

Different classification systems exist for acute lateral ankle injuries, based on anatomy versus physical findings. Three anatomic grades of severity have traditionally classified lateral ankle ligament injuries [17]. A mild or Grade I sprain is mostly a ligament stretch rather than a tear. There is minimal swelling, mild tenderness, and no mechanical joint instability, which allows the patient to bear weight comfortably. A moderate or Grade II ligament sprain is defined as a torn ATFL with an intact CFL. There is moderate swelling and tenderness, and more difficulty with weight bearing. A severe or Grade III ankle sprain is a complete tear of both the ATFL and CFL. There is marked swelling and often more diffuse tenderness, ecchymosis over a few days, and inability to bear weight.

Prevention

Prevention is always preferable to treating an injury. For this reason, sports medicine research has focused its attention on methods to reduce the incidence of ankle sprains. Rovere and Clarke [18] demonstrated in a retrospective study that a combination of a lace-up ankle brace and a low-top shoe significantly decreased the number of ankle sprains. Taping of the ankle improved proprioception before and after exercise, although taping is not without its limitations. Education of the athlete through injury awareness and proprioceptive training with a balance board can reduce the recurrence of acute ankle sprains. Prophylactic taping of the ankle joint combined with high-top shoes has been found to significantly decrease the number of ankle sprains [19]. The mechanism behind taping the ankle is not well understood. Although it provides an external splint to the ligaments, it only reduces range of motion for 2 to 3 hours of physical activity [20]. Ankle taping creates irritation and is rather expensive.

Treatment of acute lateral ligament injuries

Balduini's functional conservative treatment for Grade I and II injury consists of three phases [1]. The initial rest, ice, compression, and elevation (RICE) treatment is followed by a short period of protection with supportive bandaging, taping, or bracing, and finally by early active range-of-motion exercises, proprioceptive training with a tilt-board, and strengthening exercise for the peroneus muscle. It is important to keep the ankle in neutral or dorsiflexion, often by the use of ankle brace, as dorsiflexion was shown to reapproximate the fibers of the ATFL. In a study of the US cadets treated with this regimen, the average disability was 8 days for a Grade I injury and 15 days for a Grade II injury [21].

The treatment of Grade III lateral ligament tears is not as clear cut. Satisfactory subjective results have been obtained with either primary repair [22] or conservative treatment in several studies [23]. In a classic literature review by Kannus and Renstrom, 12 prospective randomized studies with a mean follow-up time of 6 months to 3.8 years compared acute repair versus cast immobilization versus early controlled mobilization. Return to work was two to four times faster in the functionally treated group compared with the patients treated by either surgery or cast immobilization [24]. No differences were observed in any study with regard to pain, swelling, or stiffness with activity. Incidence of chronic functional instability did not appear to be different between patients receiving functional treatment and those receiving surgical repair. Kaikkonen found that 87% of functionally treated patients had excellent to good results 9 months after injury, whereas only 60% of the surgically treated patients had those results. In summary, early controlled mobilization (functional treatment) proved to provide the quickest recovery in ankle mobility and an earlier return to work and physical activity without compromising the lateral mechanical stability of the ankle. Secondary surgical repair of the ruptured ankle ligaments (delayed anatomic repair) could be performed even years after the injury if necessary, with results that were comparable to those achieved with primary repair.

Functional rehabilitation program

Biological background

Four stages characterize the biology behind functional treatment of acute lateral ankle ligament tears:

First, immediately after the injury the RICE program should be instituted to minimize hemorrhage, swelling, inflammation, and pain for best possible conditions for healing [25].

Second, the ligaments have to be protected during the following 1 to 3 weeks. This period is called the healing or proliferation phase. During this interval the fibroblasts invade the injured area and proliferate to form collagen fibers. Protection in the form of tape or brace should be used during this time. Vaes et al [26] found that the radiographic talar tilt in athletes with functional instability was decreased during an inversion moment in braced compared with unbraced ankles.

Third, 3 weeks after the injury, the maturation phase begins, during which the collagen fibers mature and become scar tissue. Controlled stretching of muscles and movement of the joint not only encourage the orientation of the collagen fibers along the stress lines, but will also prevent the deleterious effects of immobilization on joint cartilage, bone, muscle, and tendons.

Fourth, after 6 to 8 weeks the new collagen fibers can withstand almost normal stress, and full return to activity is the goal. The entire maturation and remodeling of the injured ligaments lasts from 6 to 12 months.

Treatment modalities

Ankle mobilization. The early phases of treatment should begin with low resistance such as stationary cycling or swimming, with weight bearing as tolerated as soon as possible. Only once normal weight bearing and pain-free range of motion are achieved can muscle strengthening begin. Assisted eversion exercises should be performed in dorsiflexion to strengthen the peroneus brevis and tertius, and in plantar flexion to strengthen the peroneus longus.

Proprioception. Once muscle strength has improved enough to support balance, then proprioception training begins, including the use of a tilt board. The goal of proprioception training is to improve balance and neuromuscular control.

Additional forms of treatment. Of the different types of physical therapy modalities, only cryotherapy has been proven to be effective [27]. We do not recommend injection of cortisone into the ankle joint or ligaments. Nonsteroidal anti-inflammatory medications (NSAIDs) were found to be more effective than placebo in treating ankle tenderness and swelling during the first 2 weeks after the injury, but the differences were small and seemed to disappear during an extended follow-up [28]. Ointments and creams offer no benefit for ankle sprains. Aspiration of the ankle joint is of little value and carries an element of risk. When moist heat packs, warm whirlpool baths, electrogalvanic stimulation, and intermittent pneumatic compression (IPC) modalities were compared, only the IPC device was showed in randomized prospective studies to decrease swelling [28]. In the authors' clinical practice, for severe or Grade III lateral ankle sprains we often use a fracture boot or short leg cast, full weight bearing, for the first 5 to 7 days. This allows the patient to eliminate the need for crutches and makes activities of daily living, including working and child care, much easier. In addition, we have found this tends to decrease the swelling and pain in a more rapid fashion.

Surgery

As mentioned above, no major difference has been found in the outcome of patients treated with primary repair of the torn ligaments compared with functional treatment. At this time, the orthopedist rarely performs acute repair of the lateral ligaments. Most authors agree that the preferred treatment in acute lateral ligament ankle injury is functional treatment. The authors have performed acute repair of torn ligaments in rare situations, one example being an open-ankle dislocation with gross disruption of the lateral ankle ligaments. Leach and Schepsis in 1990 argued that primary repair of torn ligaments should be undertaken in young athletes with a Grade III injury [29].

Chronic lateral ankle instability

Presentation

In cases of isolated chronic lateral ankle instability, the main complaint is intermittent "giving out of the ankle." There is usually a history of at least two or three severe lateral ankle sprains. Patients have difficulty on uneven surfaces and are apprehensive about another giving-way episode that will cause pain and temporary dysfunction. These giving-way episodes are often associated with mild injury to the attenuated ligaments and short-term dysfunction (2–3 weeks). Between the giving-way episodes, patients are typically without pain and do not experience swelling, catching, or locking. Taping or an ankle brace usually helps to a certain degree; however, difficulties persist due to a combination of lateral ankle laxity, altered proprioception, and strength deficits.

Physical examination

Physical examination concentrates on the status of the lateral ankle ligaments through the use of ankle stability tests; however, a careful evaluation is performed to assess for potential contributing factors. Extremity alignment is noted, especially the association of possible hindfoot varus. If hindfoot varus malalignment is present, this will also need to be addressed if successful nonoperative or operative treatment is expected. Hindfoot motion is also evaluated to rule out potential existence of tarsal coalition, especially in the young athlete. The status of the peroneal muscles, which are often weak, are also assessed by manual muscle strength testing. In addition, signs of generalized ligamentous laxity are noted, because this also affects the results of nonoperative and operative treatment. Unless there is a history of a recent sprain, the ligaments are not typically tender to palpation or stress. Inspection and palpation of the ankle should also rule out unexpected bony or soft-tissue swelling or tenderness.

Stability tests

The two most common tests used to assess lateral ankle stability are the anterior drawer test and the talar tilt test.

The anterior drawer test. The anterior drawer test is designed to indicate the amount of damage incurred to the ATFL, as indicated by the amount of anterior translation of the talus with respect to the tibia. The patient is seated with the knee flexed during the examination. The test is performed by holding the calcaneus with one hand while stabilizing the distal tibia with the other and translating the calcaneus forward. Positioning the ankle in 10° of plantar flexion was found to improve the sensitivity of the test. Increased translation indicates incompetence of the ATFL [30]. The amount of anterior translation is noted, as well as whether a solid end point is appreciated. The authors have found that placing the index finger and thumb in the anterior joint while the hypothenar eminence stabilizes the tibia allows for better appreciation of the anterior movement of the talus in relation to the tibia. This tactile sensation is felt to be more important than absolute radiographic parameters when assessing the status of the lateral ankle ligaments.

In addition, the authors use the anterior drawer test to also learn more about the condition of the CFL. This is done by performing the anterior drawer test with the ankle in dorsiflexion, and thus placing the CFL under tension. Increased translation with a weak end point in plantar flexion that then produces a solid end point in ankle dorsiflexion is felt to represent an attenuated ATFL but a functioning CFL. This clinical scenario is felt to more likely represent functional instability rather than mechanical instability. Increased translation with a soft end point in both plantarflexion and dorsiflexion likely represents an incompetent CFL in addition to ATFL. The authors find the anterior drawer test to be a very helpful clinical test, especially when comparing a symptomatic with an asymptomatic contralateral ankle.

Less emphasis is placed on radiographic numbers associated with an anterior drawer test, yet these stress radiographs are helpful in unclear clinical situations, and some authors find them very useful. Karlsson [31] defines normal anterior translation as between 2 mm and 9 mm. Abnormal laxity on the anterior drawer test is defined as an absolute anterior displacement of 10 mm, or 3 mm more than the contralateral side.

The talar tilt test. The talar tilt test is used to help evaluate the status of the calcaneal-fibular ligament. First described by Faber in 1932, the talar tilt test is the angle formed during forceful inversion of the hindfoot between the talar dome and the tibial plafond. While the tibiotalar joint is held in a neutral position, one hand stabilizes the distal tibia and the other hand rotates the talus and calcaneus as a unit into inversion. During physical examination, it can be difficult to differentiate tibiotalar motion from subtalar motion; however, with stress radiographs each joint can be individually evaluated. The talar tilt test is more helpful as a radiographic stress test than as a physical examination technique. Incompetence of the ATFL and CFL each contribute to an increased talar tilt, but it is the CFL that is most directly evaluated. Controversy exists regarding how much talar tilt is physiologic, with normal values being reported by Cox as being between 5° and 23° [32]. For this reason, it is best to compare the injured side to the contralateral normal side. The authors view the talar tilt test as a diagnostic tool that is not depended on in routine cases, but can add valuable information when the diagnosis in unclear.

Proprioception

The feeling of giving way is an indication of a proprioceptive defect in the ankle. Studies have shown up to 86% peroneal and 83% tibial nerve injury due to stretch following Grade III ankle sprains, as diagnosed by electromyography [33]. Damage to the nerve can occur after as little as 6% stretch in the nerve. Proprioception is best assessed with a modified Romberg test, or stabilometry in the case of chronic ankle instability. The Romberg test is performed by asking the patient to stand first on the normal ankle with eyes open then closed, after which the process is repeated on the injured limb.

Associated injuries

As noted previously, patients with isolated chronic lateral ankle instability have pain that is intermittent and associated with specific inversion episodes. Although the lateral ligaments are the structures most frequently damaged with recurrent ankle inversion injuries, many structures have the potential for injury. These potential associated injuries are listed in Box 3. Patients suffering from associated injuries complain of ankle pain and disability between these instability episodes. Recent reports have noted that it is not uncommon for these patients with chronic lateral ankle instability to have additional injuries.

In 2000, DiGiovanni et al reported on the type and frequency of associated injuries found at the time of surgery for chronic lateral ankle instability. At surgery, none of the 61 patients was found to have isolated lateral ligament injury. Fifteen different associated injuries were noted. The injuries found most often by direct inspection included: peroneal tenosynovitis, 47/61 patients (77%); anterolateral impingement lesion, 41/61 (67%); attenuated peroneal retinaculum, 33/61 (54%); and ankle synovitis, 30/61 (49%). Other less common but significant associated injuries included: intra-articular loose body, 16/61 (26%); peroneus brevis tear, 15/61 (25%); talus osteochondral lesion, 14/61 (23%); and medial ankle tendon tenosynovitis, 3/61 (5%) [34]. In 1999, Komenda and Ferkel reported on arthroscopic findings associated with ankle instability. Before lateral ankle reconstruction, ankle arthroscopy was performed on 54 patients with chronic ankle instability. At surgery, 51 ankles (93%) had intra-articular abnormalities, including loose bodies in 12 (22%), synovitis in 38 (70%), talus osteochondral lesions in 9 (17%), ossicles in 14 (26%), osteophytes in 6 (11%), adhesions in 8 (15%), and chondromalacia in 12 (22%) (12) [35].

Nonoperative management

A functional treatment protocol, often using physical therapy, is the mainstay treatment for chronic lateral ankle instability. It has a high chance of success in patients with functional ankle instability, as well as those with mechanical instability who demonstrate peroneal muscle weakness and proprioception deficits.

The length of treatment can vary widely and depends on the initial functional deficiency and the intensity of treatment. In general, a trial of at least 6 weeks of aggressive physical therapy is suggested before considering operative treatment.

Contributing factors need to be considered and addressed as indicated. For patients with flexible hindfoot varus, an orthosis with a lateral heel wedge can be beneficial. A lateral flare to be added to an athletic shoe can be prescribed for

Box 3. Potential associated injuries in patients with chronic lateral ankle ligament instability

Nerve injury

Superficial peroneal nerve dysfunction (most common)
Sural nerve or tibial nerve dysfunction

Soft tissue injury

Anterolateral ankle impingement (proliferative synovitis and scar)
Sinus tarsi syndrome

Tendon injury

Peroneus brevis tear
Peroneal retinaculum attenuation (peroneal tendon instability)
Peroneal longus tear
Os peroneum syndrome
Medial ankle tendons (PT, FDL, FHL)

Osteochondral defects (OCD)

Anterolateral talus
Posteromedial talus
Distal tibia
Loose body in ankle joint
Chondromalacia

Ligament injury

Subtalar instability
Syndesmotic injury

Bone injury

Malleoli stress fracture
Posterolateral process talus nonunion or os trigonum
Lateral process talus nonunion
Anterior process calcaneus nonunion
Base fifth metatarsal nonunion
Tibiotalar anterior bony impingement
Tarsal coalition: bone/cartilage/fibrous

patients with stiffness in hindfoot and a varus position. A heel lift may help decrease anterior impingement syndrome by opening the anterior tibiotalar joint. Taping of the ankle is beneficial initially; however, the initial support decreases by 50% after 10 minutes of exercise and provides no support after 1 hour of exercise [36]. An Air-Stirrup ankle brace (Aircast, Summit, New Jersey) has proven to significantly decrease inversion and eversion range of motion, and its effect did not decrease with exercise [37].

Operative treatment for chronic ankle instability

The indication for lateral ligamentous reconstruction of the ankle includes persistent, symptomatic, mechanical instability that has failed a functional rehabilitation program. Contraindications to ligament reconstruction include pain with no instability, peripheral vascular disease, peripheral neuropathy, and inability to be compliant with postoperative management.

As noted previously, associated injuries in patients with chronic lateral ankle instability are not uncommon and should be evaluated for. In patients suspected of having associated injuries, either intra-articular or extra-articular, the authors find ankle MRI very helpful. As noted by Komenda and Ferkel [35], ankle arthroscopy is useful to evaluate for potential intra-articular associated pathology; however, ankle arthroscopy is not mandatory because direct inspection of the joint is possible during the ligament procedure.

More than 80 surgical procedures have been described. In general terms, they can be classified as either anatomic repair of the lateral ligaments or nonanatomic repair that involves tendon weaving procedure. The authors prefer an anatomic repair technique for the majority of patients, specifically using the Brostrom-Gould technique. The Reconstructive tenodesis procedures preferred by the authors are the Brostrom-Evans and the Chrisman-Snook procedures. These are usually reserved for revision procedures or for patients with generalized ligamentous laxity, or heavy athletes such as football linemen. For almost all these procedures described in the literature, the reported success rate is greater than 80%.

Brostrom-Gould anatomic lateral ligament repair

In 1966, Brostrom reported on 60 patients who underwent direct late repair of the lateral ankle ligaments for chronic lateral instability (Fig. 2). The ATFL and CFL torn ends were shortened and repaired directly by midsubstance suturing [38]. Gould modified this procedure in 1980 by advancing the lateral aspect of the extensor retinaculum over the Brostrom repair [39]. This modification reinforces the repair, limits inversion, and helps to correct the subtalar component of the instability. The surgical procedure involves either of two approaches. If no extra-articular pathology is expected, an anterior approach along the anterior and distal border of the fibula is used. If peroneal tendon or peroneal retinacular pathology is present, however, then a more extensile posterior approach following the course of the peroneal tendons is used. The superficial peroneal nerve

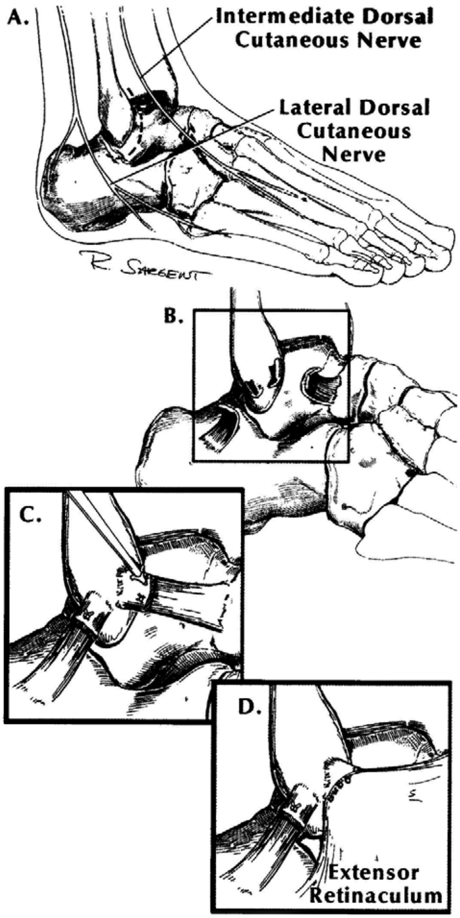

Fig. 2. Brostrom-Gould anatomic lateral ligament reconstruction. (*A*) Relationship between the sensory nerve branches and the incision (*dotted lines*) for the Brostrom-Gould anatomic repair. (*B*) Anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) midsubstance tears. (*C*) Brostrom repair of the ATFL and CFL. (*D*) Mobilization of the proximal portion of the inferior extensor retincaculum to the fibula; the Gould modification of the Brostrom ligament repair. (*From* Baumhauer J, O'Brien T. Surgical considerations in the treatment of ankle instability. J Athl Train 2002;37(4): 458–62; with permission.)

is identified and protected during exposure of the ankle capsule. The ATFL is divided midsubstance by making an anterolateral arthrotomy. The CF ligament is next identified under the peroneal tendons and also divided midsubstance. The ATFL and CFL are shortened by imbrication in a vest-over-pants fashion and repaired using two to three strands of 2-0 Ethibond. This technique of imbrication results in tightening and doubling the thickness of the lateral collateral ligaments. The CFL sutures are tightened with the ankle in plantar flexion and eversion, whereas the ATFL sutures are tied while the heel is "hanging" to avoid anterior subluxation of the talus. The Gould modification is then performed by advancing the extensor retinaculum and securing it to the fibula. At the procedure's end, a plaster posterior splint with side struts (ankle stirrup) is applied and maintained for 2 weeks. A weight-bearing cast is then applied for 4 weeks, followed by an ankle brace, and a functional rehabilitation program is prescribed.

The benefits of the procedure include maintaining normal ligamentous anatomy, avoiding need for tendon grafts, and most importantly preserving physiologic tibiotalar and subtalar motion. The disadvantage is that it relies on the quality of the tissue for a strong repair. This procedure has shown 95% good-to-excellent results in the hands of Hamilton et al in 1993 [40], and they noted it is particularly well suited for professional dancers or for those whose livelihood necessitates a full range of ankle motion. In 1988 Karlsson et al [41] found excellent or good results in 80% of the patients at a 6-year follow-up. The only poor results were found in patients who had prolonged instability, osteochondritis of the ankle, and generalized ligamentous instability. In the authors' clinical practices, the Brostrom-Gould has become the workhorse procedure for chronic lateral ankle instability, with typically highly favorable results.

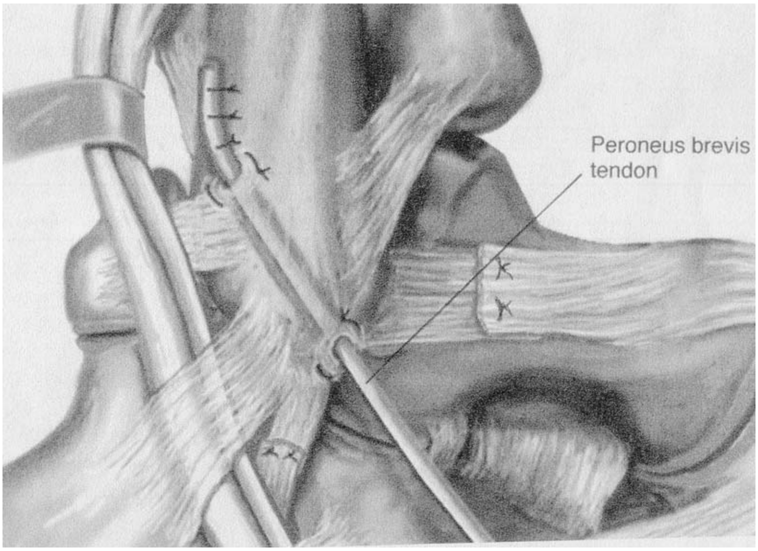

Fig. 3. The modified Brostrom-Evans procedure for chronic lateral ankle instability. End-to-end Brostrom anatomic repair (shortening with imbrications) of the anterior talofibular and calcaneofibular ligaments. This is followed by adding the Evans reconstructive lateral ankle tenodesis. The anterior half of the peroneus brevis tendon is harvested, maintaining distal attachment to the fibula. It is then routed anterior to posterior through a drill in the distal fibula and secured at entrance and exit sites. (*From* Gerard P. Clinical evaluation of the modified Brostrom-Evans procedure to restore ankle stability. Foot Ankle Int 1999;20:246–52; with permission.)

Modified Brostrom-Evans procedure

In 1953, Evans described releasing the peroneus brevis at the musculotendinous junction, rerouting it through the fibula, and reattaching it to its proximal stump [42]. This was later modified, suturing the tendon back to itself instead of reattaching it to the proximal stump [43]. In 1999, Girard et al reported on the results of a procedure that augments the Brostrom-Gould anatomic repair technique by using the anterior one third of the peroneus brevis in a tenodesis fashion. This procedure is referred to as the modified Brostrom-Evans procedure, and is outlined in Figs. 3 and 4 [44]. The postoperative protocol is similar to that following the Brostrom-Gould procedure. The main advantage of this procedure is that it adds static restraint without a significant sacrifice of dynamic peroneal restraint. This procedure has a role in heavy athletes such as football lineman, generalized ligament-laxity patients, or as revision surgery. Girard et al reported on the results of 21 patients with an average follow-up of 29.5 months [44]. They noted a significant loss of inversion compared with the uninjured contralateral side, but no change in range of motion and no significant loss of peroneal strength.

Chrisman-Snook reconstruction

The authors use this reconstructive tenodesis procedure primarily for revision surgeries. Of the various reconstructive tenodesis procedures, it is favored because it most closely parallels the native lateral ligament anatomy. Elmslie introduced a nonanatomic, lateral ligament reconstruction that passes a strip of

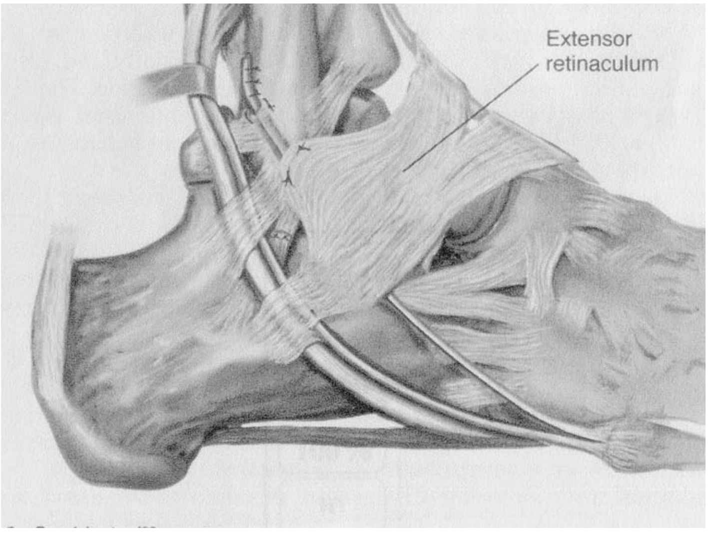

Fig. 4. Gould modification as the final step. The proximal portion of the inferior extensor retinaculum is advanced to the distal fibula to further stabilize both the tibiotalar and subtalar joints. (*From* Gerard P. Clinical evaluation of the modified Brostrom-Evans procedure to restore ankle stability. Foot Ankle Int 1999;20:246–52, with permission.)

fascia lata through drill holes in the fibula and the calcaneus [45]. This was later modified in 1969 by Chrisman and Snook, using a split portion of the peroneus brevis instead of the strip of fascia lata [46]. The surgical approach involves making a posterior curvilinear incision from 4 cm to 5 cm proximal to the tip of the fibula to 2 cm proximal to the tip of the fifth metatarsal. Skin flaps are developed and the anterior slip of peroneus brevis is released from its musculotendinous junction. The anterior portion of the peroneus brevis tendon is passed through either the base of the ATFL or through a bone tunnel in the talus, followed by passing it through a bone tunnel through the fibula to recreate the insertion of the CFL tendon, and finally anchoring it into the calcaneal origin of the CFL tendon.

In a 1985 long-term follow-up study, Snook et al found 79% excellent results and 14% fair results at an average 10-year follow-up [47]. Although it allows for a stable ankle joint, it does not allow for physiologic motion. It creates excessive restriction of the ankle and subtalar joint motion, and thus patients often find it difficult to adjust to uneven terrain. In our clinical experience, we have found that it is not uncommon to see patients 10 to 20 years after this procedure who have since developed significant degenerative joint disease (DJD) of subtalar joint, most likely secondary to nonphysiologic stresses on the joint over time.

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