Acute Lateral Sprained Ankle Syndrome
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Introduction
The sprained ankle is a common musculoskeletal disorder occurring at an estimated rate of 1 per 10,000 persons per day. It has been well-studied in individuals engaging in sporting activities. The ankle is one of the most commonly injured body sites in sports, and in most sports, sprains are the most commonly occurring ankle injury. While the number of visits for ankle sprains to ambulatory care facilities such as offices or clinics is not known, in the United States during 2005, there were 115.3 million emergency department visits; of which 4.5% (approximately 5.2 million) were attributed to injury of the lower leg and ankle.

Approximately 85% of ankle sprains result from inversion injury of the plantarflexed foot while the remaining 15% are usually due to eversion. Consequently, the primary anatomic structure injured is the lateral ligamentous complex. Although injury is primarily ascribed to the anterior talofibular and calcaneofibular ligaments, it has become clear that other structures may also be simultaneously injured. As such, the term “sprained ankle syndrome” has been advocated as a more robust term to better reflect the diverse spectrum of this injury. The complex nature of this seemingly simple injury is reflected in the relatively high numbers of individuals that have persistent symptoms or recurrent problems despite treatment.

The purpose of this article is to present a clinically focused review of this common injury, and to discuss recent evidence-based recommendations regarding appropriate management.

Anatomy
The lateral malleolus, tibial plafond, and medial malleolus define the ankle mortise which articulates with the dome of the talus (Image 1). The talus dome is wide anteriorly, then narrows posteriorly. To accommodate this, the distance between the malleoli is greater anteriorly than posteriorly. This allows for a snug fit between the malleoli and talus when the foot is in a neutral or slightly dorsiflexed position. The articular surface of the ankle carries the largest load per square centimeter of any body joint.

Figure 1
Image 1: Bone structures of the ankle joint.
The stability and function of the ankle joint is dependent upon the integrity of the ankle mortise. Stability is provided by the tibiofibular syndesmosis, the ligamentous attachments of the mortise and talus, and the tendons interlocking the articular surfaces. Ligamentous attachments between the mortise and talus include two major groups: 1) the lateral ligamentous complex which provides lateral stability, and 2) the deltoid ligament which provides medial stability. The lateral ligamentous complex is comprised of three separate ligaments: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). The leg musculature also provides an important dimension of dynamic compressive stability via multiple tendinous insertions on various areas of the foot. Of particular importance with regard to lateral ankle stability are the peroneus brevis which inserts at the base of the fifth metatarsal, and the peroneus longus which inserts at the base of the first metatarsal and medial cuneiform.

While the foot is in its neutral stable position, the ATFL is relaxed and CFL is under tension. During jumping, the foot naturally assumes a plantar flexed and inverted position. This places the ATFL in a position primed for injury. Additionally, since the ATFL is an extension of the joint capsule, injury to this ligament may also result in a capsular tear. If injuring forces continue beyond disruption of the ATFL, the CFL and PTFL have been shown to sustain injury in succession.

In addition to these typically injured ligamentous structures, injury to other adjacent areas may also occur. These include the talocrural articular cartilage, bifurcate calcaneocuboid and talonavicular ligaments, subtalar ligaments, extensor digitorum brevis, sinus tarsi, Achilles tendon, tibiofibular syndesmosis, and avulsion or compression fractures. Direct nerve injury (eg. superficial peroneal nerve) has also been reported.

CLINICAL EVALUATION

In addition to obtaining a routine history, there are several key elements which are important to elicit. As best as can be determined, elucidation of the mechanism of injury is important as it helps guide the physical examination. Presence of any clicking or popping, or inability to bear weight immediately following the injury is useful for stratifying fracture risk in determining the need for radiography. History of prior ankle injury is also important to establish. Not only are these individuals more prone to recurrent injury, but they are likely to require specialist consultation in optimizing their care.

Physical examination should include evaluation of soft tissue structures and bones of the knee, leg, ankle, and foot. The limb must be inspected for areas of swelling and ecchymosis, and palpated for areas of tenderness, with notations made of joint range of motion. Surface anatomic locations of the specific lateral ligamentous complex structures are shown in Image 2.

**Figure 2**
Image 2: Surface anatomic locations of the ATFL, CFL & PTFL.

Delineation of areas of maximal point tenderness and swelling is useful in indentifying at least some of the specific structures injured, and for quasi-quantification of the extent of soft tissue injury. The anterior drawer (Image 3) and talar tilt (Image 4) tests may also be performed, either as clinical examinations or as evaluations of joint stability under stress during radiography. Although these tests are described here, their usefulness has been called into question for two main reasons. First, there is wide individual variation in measurements making normal ranges difficult to define, and second, demonstration of ligamentous laxity after acute injury does not strongly correlate with development of chronic symptoms.
The anterior drawer test can be performed with the patient sitting and the knee flexed. With the ankle in a neutral position, the heel is grasped firmly with one hand, and is pulled anteriorly while the distal tibia is stabilized with the opposite hand. A positive test demonstrates anterior translation of the talus. Additionally, a sulcus may be seen on either the medial or lateral anterior surface of the ankle joint. A comparison with the uninjured ankle should also be performed. When this maneuver is evaluated using a lateral x-ray study of the ankle, anterior subluxation of the talus greater than 3 mm is considered to be indicative of ATFL injury.

The talar tilt test can be performed with the patient sitting and the knee flexed. With the ankle in neutral position, the heel is grasped with one hand. The ankle is then passively adducted. A talar tilt greater than 10° compared with the uninjured ankle is considered positive, and is indicative of combined ATFL and CFL injury. Since this threshold may be difficult to resolve visually, actual measurements can be obtained radiographically using either the anterior-posterior or mortise view. As depicted in the skeletal images above, the normally parallel lines formed by the tibial plafond and talar dome now intersect to form the angle to be measured. This measurement is then compared with any such angle produced in the contralateral ankle when an adduction stress of equal magnitude is applied.

These tests require the patient to be very relaxed and cooperative. They are difficult to perform and interpret in the patient with an acutely injured ankle, and may require soft tissue or intraarticular administration of local anesthesia for optimal examination. Additionally, the accuracy of these tests is also a function of the force applied by the examiner, potentially adding a layer of inter-examiner variability to test results. Considering the low yield of useful information...
obtained from these tests acutely, and the minimal impact this information has on initial treatment strategy, these tests are probably best reserved for when the ankle is reevaluated after the acute insult.

Although the lateral ligamentous complex is the most frequently injured, medial ankle tenderness should raise the suspicion of a deltoid ligament sprain and its associated injuries. These are very important injuries to recognize, but are beyond the focus of this article.

Ankle range of motion (ROM) is also known to have considerable inter-individual variation. In a report on normal ranges of motion of 192 ankles in men aged 30-40 years, Roaa et al reported (rounded figures) 15° of dorsiflexion, 40° of plantarflexion, and 30° of inversion and eversion.9

Palpation of the foot should include the hindfoot, midfoot, and forefoot. In particular, examination of the talocrural joint, talar dome, medial malleolus, calcaneocuboid and talonavicular ligaments, subtalar joint, and the various areas of tendinous insertions (eg. peroneus brevis attachment at the base of the fifth metatarsal) should be performed. Sensation should be evaluated over the first dorsal web space (deep peroneal nerve), lateral dorsal foot (superficial peroneal nerve), lateral border of foot (sural nerve), medial dorsal foot (saphenous nerve), and the medial and lateral plantar foot and heel (medial and lateral plantar & medial calcaneal nerves). Motor examination tests both intrinsic and extrinsic foot musculature, and includes the ability to flex and extend the toes, inversion, eversion, plantarflexion and dorsiflexion. Vascular examination includes palpating both the dorsalis pedis and posterior tibial pulses, and checking for digital capillary refill.

Using clinical criteria, most ankle sprains are graded I, II & III with respect to increasing severity. Grade I is a mild injury with minimal swelling and tenderness, slight or no functional loss, with stability to anterior drawer and talar tilt tests. There is presumed partial tear of the ATFL, but patients are able to perform their normal activities with only slight pain. Grade II is a moderate injury with diffuse swelling and tenderness, moderate functional loss, with mild instability to anterior drawer and talar tilt tests. There is partial to complete ATFL tear, and possibly partial tear to CFL. Patients cannot perform normal activities, and there is moderate to severe pain with weight bearing. Grade III is a severe injury with marked swelling and tenderness, significant functional loss, with gross instability to anterior drawer and talar tilt tests. There is complete tearing of the ATFL, CFL and PTFL, and the patient is completely unable to bear weight.

Although still underutilized, the Ottawa ankle rules (Table 1) provide a well-validated set of clinical decision rules to guide the assessment of ankle injuries with regard to the need for radiography.

<table>
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<th>Table 1: Ottawa ankle rules.</th>
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<td>X-rays are required only if there is bony pain over the malleolar or midfoot area, and any one of the following:</td>
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<td>- Bone tenderness along the distal 6 cm of the posterior edge of the tibia or tip of the medial malleolus.</td>
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<tr>
<td>- Bone tenderness along the distal 6 cm of the posterior edge of the fibula or tip of the lateral malleolus.</td>
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<tr>
<td>- Bone tenderness at the base of the fifth metatarsal (for foot injuries).</td>
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<td>- Bone tenderness at the navicular bone (for foot injuries).</td>
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<tr>
<td>- Inability to bear weight both immediately after the injury, and for 4 days in the emergency department or office (within 10 days of injury).</td>
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In a systematic review on the accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot, Bachmann et al, reported pooled sensitivity for adults as 97.3% (95% CI: 95.7%-98.6%), and median specificity as 36.6% (interquartile range: 22.3%-46.1%). For children, pooled sensitivity was 99.3% (95% CI: 98.3%-100%), and median specificity was 26.7% (interquartile range: 23.8%-35.6%). While physeal injuries are always of concern in the pediatric population, the Ottawa ankle rules have been shown to be quite robust even within this group.

**TREATMENT**

The goals in treating acute lateral ankle sprains are to limit disability and prevent reinjury. There are essentially three main modalities used to treat acute ankle sprains: 1) surgery, 2) conservative treatment with cast immobilization, and 3) functional treatment. In a series of meta-analyses, Kerkhoffs et al found insufficient evidence in randomized controlled trials to determine the relative effectiveness of surgical and conservative treatment for acute lateral ankle sprains. Conversely, functional treatment was determined to be the favorable strategy for treating these injuries when compared with immobilization. Outcome measures studied included: return to sports and work, pain, swelling, subjective and objective instability, recurrent sprain, range of motion, and patient satisfaction.

Functional treatment involves a program of therapy that combines the use of external ankle support, early mobilization, and proprioceptive training. This method provides the quickest recovery to full ROM, and return to work and activity; all without compromise to joint stability. The cornerstone of this concept is allowing functional use of
the injured ankle to the greatest extent possible, guided by
the patient's symptoms. This treatment modality can be
divided into three successive, but overlapping phases. While
a patient's individual progress through these phases depends
upon the extent of injury and symptoms during treatment,
the desired end-point is return of full ROM, strength, and
proprioception with no pain.

The first (acute) phase of treatment begins immediately after
injury, and generally lasts from 1-3 days. It consists of
protection, rest, ice, compression and elevation (PRICE),
and has as treatment goals, minimizing swelling and
beginning ambulation as tolerated. Application of an
external ankle support can address both protection, and
compression. While numerous types of external ankle
support are available, Beynnon et al showed that individuals
sustaining grade I, II, and possibly grade III first-time ankle
sprains had earlier return to preinjury function when treated
with combined application of an elastic wrap and air-stirrup
brace.\textsuperscript{14} (Image 5)
protects against inversion reinjury. For grade III sprains, some authors advocate more protection and support (eg. walking orthosis, posterior molded splint or short leg cast) for 1-6 weeks prior to functional treatment. However, this has been repeatedly shown to increase the period required for rehabilitation, and does not provide any discernibly positive long-term benefit with regard to mechanical joint stability.\textsuperscript{13-14}

The period required for relative rest varies with each individual, and is dependent upon factors such as extent of injury, use of analgesics and individual differences in pain tolerance. While exercises designed to restore motion and strength commence soon after injury, weight bearing should be limited with its progress dictated by the degree of pain with ambulation. Initially, weight bearing may simply consist of placing the involved foot flat on the floor in a sitting or standing position, and shifting the applied weight in an anterior to posterior and medial to lateral direction. Assistive devices such as crutches or cane should then be used with increasing ambulatory progression as the patient moves from weight bearing as tolerated to pain-free gait, at which time, their use may be discontinued. Although most patients report a rapid decrease in pain within the first 2 weeks following injury, patients with grade I injuries typically return to normal walking and stair climbing by 5 days, and those with grade II injuries by 10-12 days following their injury when treated with combined elastic wrap and air-stirrup support.\textsuperscript{14,15} Cryotherapy (eg. application of crushed ice in a plastic bag separated from the skin by a thin cloth) is considered beneficial, primarily for pain relief, when applied for 20 minutes every 2 hours for the first 72 hours following injury. The effect may be enhanced by dividing the 20 minute application time into two separate 10 minute applications separated by a 10 minute rest interval.\textsuperscript{16} Finally, elevation is recommended for edema reduction. Edema is a physiological response to soft tissue trauma, and is a significant hindrance to the healing process. It is also a major cause of pain and disability. As with compression, elevation prevents soft tissue fluid accumulation. Maximum swelling generally occurs within the first 48 hours after injury. Thus, the leg should be elevated as much as possible above the level of the heart during this time, and as needed thereafter.

Early in the course of PRICE therapy, ROM exercises in the stable planes of movement should be initiated to prevent stiffness, and to enhance lymphatic drainage of interstitial fluid. For grade I injuries, ROM exercises can begin the day of injury, whereas grade II injuries may require 48-72 hours for some resolution of pain and swelling prior to exercise commencement. It is unclear as to when ROM exercises should be started in individuals with grade III sprains. However, it appears that here too, exercises may be started as soon as pain and swelling begin to resolve.\textsuperscript{14} These exercises consist of passive and active plantarflexion and dorsiflexion, and active clockwise and counterclockwise rotations of the foot (eg. drawing the entire alphabet in small case and capitalized letters). Passive stretching of the gastrocnemius-soleus complex, and Achilles tendon is demonstrated in Image 6.

Figure 7
Image 6: Passive stretching of the gastrocnemius-soleus complex and Achilles tendon using a towel wrapped around the ball of the foot with application of manual traction.

A short course (3-7 days) of nonsteroidal antiinflammatory drug (NSAID) use has been suggested to be of benefit to patients with acute ligamentous injuries.\textsuperscript{17} However, acetaminophen has also been shown to be as effective as ibuprofen with regard to pain relief, ability to walk, bruising, swelling, and ROM in patients with acute ankle sprain.\textsuperscript{18} Since acetaminophen does not blunt the inflammatory aspects of tissue healing, and is equally efficacious in resolving traumatic ankle edema, this may be the preferred agent.

The second (subacute) phase of treatment begins once swelling and pain has decreased, and generally lasts up to 2 weeks following injury. The purpose of this phase is to restore normal ROM, and strengthen the musculature associated with the ankle joint. The treatment goal is to have the patient ambulate fully or with only a minimal limp. During ambulation, an external ankle support should still be worn for protection. Although both cryotherapy and limb elevation may still be used during this phase for persistent edema, the effectiveness of cryotherapy beyond its use...
during the PRICE phase has not been convincingly demonstrated.19

ROM exercises as outlined above are continued during this phase. As ankle pain diminishes, gastrocnemius-soleus complex and Achilles tendon stretches can be performed by leaning against a wall with knees in full extension. When the patient can walk without pain, active inversion and eversion, and muscle strengthening exercises are initiated with progressive addition of resistance. Specifically, 3-4 sets per day of inversion and eversion exercises (Image 7), and walking 10-20 feet on tip-toes and heels; again, using pain as a guide to exercise progress.

Figure 8
Image 7: Example of active eversion against resistance using an elastic bandage. As strength and endurance increases, the elastic bandage is replaced with rubber or latex. This exercise is of particular importance in strengthening the peroneus muscle complex.

The most important factor in preventing recurrence of ankle sprain is proprioceptive training.20 Altered neuromuscular control results in balance impairment during single-leg stance functions, and increased ankle reaction times to acute angular displacements. Consequently, balance training is a key feature introduced during this phase of treatment. Initially, the patient strives to maintain balance on a flat surface for 30 seconds at a time with eyes open. After accomplishing this step, tasks of increasing complexity, such as balancing on unstable surfaces (eg. pillow, foam mat, trampoline, or wobble board) both with eyes open and closed, are then added to this regimen.

The final (functional) phase of treatment begins when there is no swelling or pain present after exercise, and there is return of 75-80% of preinjury strength.21 The patient should be able to ambulate normally, and have full range of motion and strength. Generally, this phase occurs during the 2-6 week period following injury, and ends when the patient regains full preinjury level of activity. During this phase, however, and even afterwards, if the patient engages in particularly strenuous activity, application of external ankle bracing may decrease the risk of reinjury.4 It should be noted that several months are required for ligaments to heal to their maximum tensile strength.8

This phase is essentially an expansion upon prior ROM, muscle strengthening, and proprioceptive activities. Depending upon an individual’s needs, and level of athletic activity, increasingly complex movements are added to the regimen. These include: walk-jog and jog-run combinations, backward running, and pattern running (eg. figure-of-eight). Finally, for the athlete, sport-specific exercises are introduced to return the individual to preinjury levels of activity. Mattacola et al provide an extensive overview on the rehabilitation of the injured ankle.23

If pain persists or worsens during or after functional treatment, then further evaluation is warranted. Computed tomographic (CT) scanning or magnetic resonance imaging (MRI) studies are indicated for suspected talar dome or other bony fracture, osteochondral fragment, syndesmotic sprain, or peroneal or other tendon involvement. In the acute setting, tense compartments along with pain disproportionate to the degree of injury should raise the suspicion of compartment syndrome. Chronic ankle instability, impingement syndrome, tendon subluxation, or development of chronic regional pain syndrome may also occur. Presence of any of these, or when the diagnosis is uncertain, is an indication for orthopedic evaluation.24

PERSPECTIVE
Despite conventional treatment, van Rijn et al found the following in a systematic review of the literature investigating acute lateral ankle sprains in adults. After 1 year, 5-33% of patients still experienced pain, and subjective complaints of instability ranged from 0-33% in high quality studies, and from 7-53% in low quality studies. The risk of re-sprains ranged from 3-34%, and these occurred between 2 weeks to 96 months following injury. Full recovery was
reported by 36-85% within a period of 3 years. In a 7-year follow-up study of 648 patients that were treated using a functional treatment protocol following ankle inversion injury, Konradsen et al found 32% of patients experienced residual disability. While 4% were considered severely disabled, 23% were functionally impaired by chronic symptoms. Interestingly, there was no correlation between strain severity judged at the time of injury and the frequency of residual disability, or between the area of maximal tenderness at the time of injury and the area of maximal pain at the time of follow-up. This suggests that structures other than the typical lateral ligamentous complex may be more commonly involved in inversion strain injuries than is often recognized clinically. Indeed, in addition to the lateral ligament complex, pain in one or more other areas at the time of injury was shown to predict higher degrees of residual disability upon follow-up evaluation.

Consequently, while functional treatment appears largely successful in rapidly returning the majority of patients with acute lateral sprained ankle syndrome to preinjury levels of function, it may be suboptimal in addressing healing patterns required of structures that are injured along with the lateral ligament complex.

Although the lateral ligament complex is by far the most commonly injured structure, novel cost-effective ways of examining or imaging for concomitant injuries may help to define a subset of ankle sprains that are more likely to be associated with the development of chronic symptoms. Apparently not as amenable to functional treatment, it may be that injury to these structures, at least in part, is responsible for a significant portion of residual disability following acute lateral sprained ankle syndrome. Further research is clearly needed to clarify, define, and categorize this common injury into standardized strata so that appropriate treatment may be applied or developed to optimize patient outcome and prevent reinjury.

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