INTRODUCTION

Lateral sprains of the ankle are the most frequent injuries suffered during athletic activities. Early diagnosis, functional treatment and rehabilitation are the keys to prevention of chronic ligament insufficiency. Acute ligament injuries can be divided into Grade I, II and III, depending on the damage to the ligamentous and capsular structures and the degree of instability and functional loss. The most vulnerable of the lateral ankle ligaments is the anterior talofibular ligament (ATFL), which is injured in 2/3 of all ankle ligament injuries, followed by a combined rupture of the ATFL and calcaneofibular ligament (CFL) in a further 20%\(^1\).\(^2\).

Isolated injuries to the CFL and the deltoid ligament on the medial side are infrequent.\(^3\)

Prevention by either co-ordination training using balance boards or by external support can reduce the number of ligament injuries. Ankle tape and/or functional splinting, proficiently completed by the use of Air-Stirrup\(^\circledR\) pneumatic splint are preferred by many athletes. There is hardly any place for primary surgical repair after acute ligament ruptures of the ankle.\(^4\)

The recommended treatment is a rehabilitation programme with functional treatment i.e. active range of motion exercises, co-ordination training, peroneal strengthening and early weight-bearing. Satisfactory results are reported in 80 to 90% of athletes after functional treatment.\(^1\)\(^-\)\(^6\). About 10 to 20% of patients may develop ankle problems such as pain and/or chronic instability in spite of adequate primary treatment.\(^7\)\(^-\)\(^9\). Chronic instability can be divided into functional instability and mechanical instability.\(^5\)\(^,\)\(^10\)\(^-\)\(^13\).

The factors responsible for the development of functional instability include mechanical instability, proprioceptive deficit, peroneal muscle weakness and subtalar instability.\(^13\)

Before deciding upon surgical stabilisation of the ligaments a supervised rehabilitation programme should be carried out.\(^13\) Satisfactory functional results can be expected in 50% of patients after 12 weeks on this programme.\(^13\)\(^-\)\(^15\). Surgical reconstruction of the lateral ankle ligaments may be needed for athletes with high demands on ankle stability. Several different surgical procedures for the correction of chronic lateral ankle joint instability have been described. Most of these are some kind of tenodeses, where one of the peroneal tendons is transferred, such as the Watson-Jones, Evans and Chrisman-Snook reconstructions.\(^7\)\(^-\)\(^9\)\(^,\)\(^16\)\(^,\)\(^17\). Good short-term results have been reported after most of the tenodeses, but the long-term results after the Watson-Jones and the Evans tenodeses are worse than anticipated.\(^16\)\(^,\)\(^17\).

A prolonged postoperative rehabilitation period and decreased range of motion are major drawbacks for active athletes. Anatomic ligament reconstructions with shortening, reinsertion and imbrication of the elongated ligaments – technically simple procedures with good long-term results in approximately 90% of patients – are a valid alternative to the more complex ligament reconstructions. Active postoperative rehabilitation, including early controlled range of motion training, can shorten the disability after surgery.\(^18\)\(^-\)\(^20\).
ANATOMY

The soft tissue stability is provided by the ligaments; the tibio-fibular syndesmosis, the deltoid ligament on the medial side and the three bands of the lateral ligaments i.e. the anterior talofibular ligament, the calcaneofibular ligament and the posterior talofibular ligament1-3,7.

The ATFL is an intra-articular reinforcement of the anterolateral part of the ankle joint capsule. This is a long and thin ligament, but is the main stabiliser on the lateral aspect of the ankle. The ATFL is orientated in a plane parallel to the axis of movement (flexion/extension) when the ankle is in a neutral position. The ATFL is thus a true collateral ligament when the foot is in plantarflexion. Most of all ankle ligament injuries occur with the foot in plantarflexion (inwards rotation in equinus position), where the narrowest part of the Talus is in the ankle mortise and the ankle is thus mechanically least stable. This implies that the ATFL is the most vulnerable of the three lateral ligaments and this is probably one of the reasons for the high number of injuries to the ATFL1-3,15.

The CFL runs from the lateral aspect of the calcaneus to the inside of the distal end of the fibula, is located underneath the peroneal tendon sheath superficial to the joint capsule. This means that the peroneal tendon sheath has to be opened during surgery in order to visualise an injury to the CFL and to reconstruct this ligament. The CFL is lax in all foot positions, except the extremes of inversion. The stabilising role of the CFL is thus not exactly known and it is certainly less than the role of the ATFL. The CFL provides the greatest stability to the ankle joint in slight dorsiflexion, during which this ligament acts as a true collateral ligament15.

The posterior talofibular ligament (PTFL) is a short, very thick and strong ligament. The PTFL is tight with the ankle in extension and lax in flexion. Injuries to this ligament are very infrequent15.

The main stabiliser on the medial side is the deltoid ligament, a fan-shaped, strong ligament. Injuries to the deltoid ligament are infrequent15.

Anatomic variations in shape, size, orientation and capsular relations of the lateral ankle ligaments are common. These anatomical variations should be kept in mind when deciding upon treatment of ankle ligament injuries, especially surgical treatment.

ACUTE LIGAMENT INJURIES

Sprained ankle is the most common sports-related injury, and is most prominent among 15 to 35 year-olds. This injury occurs mainly as athletic trauma. The reported incidence of ankle ligament injuries varies due to demographic differences. The incidence in high-risk sports is between 2 and 6 per 100 participants per season. It has been estimated that ankle ligament injuries constitute between 15 and 56% of injuries in sports involving running and jumping activities, e.g. soccer, basketball and volleyball. Some researchers claim that about 20 to 25% of all time lost in sport involves injuries to the ankle15,16.

Ligament injuries to the ankle are divided into:
1. Acute.
2. Chronic.

Almost all lateral ligament injuries occur with the foot rotating inwards (supination) in plantarflexion upon the externally rotating tibia, leading to anterolateral rotatory instability. When the ankle moves into increased inversion, the medial malleolus acts as a fulcrum, losing its stabilising function and increasing the strain on the lateral side. The ATFL and CFL act synergistically through the whole range of motion to control lateral ankle stability.

Ankle ligament injuries can be classified as Grade I (mild), Grade II (moderate) and Grade III (severe)5,9,16.

• **Grade I injury** includes stretching of the ligaments, but no macroscopic tear. There is minor swelling and tenderness and no increased laxity. The loss of function is minor.
• **Grade II injury** is defined as partial macroscopic tear of the ligaments, with moderate swelling, tenderness and pain. The laxity is mild to moderate and there is some loss of motion. The functional disability is moderate.
• **Grade III injury** is defined as complete tear of the ligaments and the joint capsule, with severe bruising, swelling...
and pain. There is major loss of function, reduced motion and the ankle joint is unstable.

The ATFL is the most vulnerable of the lateral ligaments. Rupture of the ATFL occurs as an isolated injury in approximately 2/3 of all ankle injuries. With increased force, the CFL is also often injured. Combined rupture of the ATFL and the CFL occurs in 15 to 25% of injuries, isolated rupture of the CFL happens in only approximately 1% and injury to the PTFL is extremely rare. Athletes with hypermobility or a previous history of ankle injury are at greater risk of ankle injuries. Over 90% of all ankle sprains involve injuries to the ligaments of the lateral aspect of the ankle. This is probably due to the fact that the ligamentous structures on the lateral side of the ankle are organised as discrete fascicular bundles, and therefore not as strong as the broad trapezoidal deltoid ligament on the medial side. The medial malleolus is also shorter than the lateral malleolus, allowing the talus to invert more than it can ever.

Isolated ligament injuries on the medial side are much less frequent (only about 2.5%). The injury mechanism is an eversion strain i.e. outward rotation of the foot upon the internally rotating tibia, resulting in a rupture of the deltoid ligament. This injury usually takes several weeks to heal and often gives rise to chronic medial pain rather than chronic instability on the medial side. It is well-known that all Grade I and Grade II ligament injuries are safely treated non-surgically. The recommended treatment is functional with a short period of rest, cooling (ice), compression and elevation to reduce the oedema (PRICE), during the first 1 to 3 days, depending upon the amount of swelling, bruising and pain. After the acute period, active range of motion training is started, followed by neuro-muscular co-ordination training using balance boards and peroneal strengthening exercises.

The ruptured ligaments should be protected from distraction and new injuries during healing, using external support i.e. ankle tape or brace to control the range of motion and to reduce the instability. Most athletes prefer ankle tape as it is easier to apply, more versatile and more functional and proprioceptive. The results after functional treatment of Grade I and Grade II ligament injuries are almost always satisfactory, and most athletes are able to return to sporting activities within 7 to 10 days, providing they protect their ankle from further injury using external support. There is still some controversy in terms of the optimal treatment of Grade III ligament ruptures as to whether these injuries should be treated non-surgically, by active functional treatment and early mobilisation, or by primary surgical repair followed by immobilisation using a plaster cast (either full or hinged). There are only a few prospective, randomised and controlled studies in the literature. All these studies have, however, showed that the long-term results are satisfactory in most patients, regardless of the primary choice of treatment i.e. surgical repair, cast immobilisation alone for 3 to 6 weeks or functional treatment with early mobilisation. Taken together, approximately 80 to 90% of patients with Grade III injuries will regain satisfactory functional stability after non-surgical treatment.

The functional treatment includes short period of immobilisation, using ankle tape, elastic bandages or ankle brace. Training of range of motion, peroneal muscles and co-ordination training is started as soon as pain and swelling have subsided. Weight-bearing is encouraged from the beginning.

The programme minimises the time for recovery, including return to sports activities and heavy labour. The functional treatment does not compromise the mechanical stability and complications are less frequent, compared with surgical repair, followed by cast immobilisation.

Since reconstructive surgery gives satisfactory results even many years after the acute ligament injury there is no strong argument in favor of early surgical repair. Furthermore, the cost, including the length of sick-leave, is lower after functional treatment when compared with primary surgical repair. This factor is of great importance, especially in times and places where resources are limited. Socioeconomical analysis shows that functional treatment is superior.

It can thus be concluded that functional treatment is the treatment of choice when dealing with acute ligament injuries of the ankle joint, irrespective of the grade of injury. The remaining problem is how to identify those approximately 10% of patients who will develop chronic functional instability in spite of adequate primary treatment and may need surgical reconstruction at a later stage.

ANKLE JOINT INSTABILITY

Ankle joint instability is defined as either mechanical instability or functional instability. Mechanical instability refers to an objective measurement e.g. standardised stress radiographs, while functional instability is a description of the subjective symptoms of the patient i.e. repeated giving-way in some cases combined with pain. Functional instability is the most common residual disability after acute lateral ligament ruptures.

The aetiological factors behind the development of functional instability...
are not exactly known, and these factors may vary\textsuperscript{15,18-20,22}. It is clear that functional instability is a complex syndrome, where mechanical, neurological, muscular and constitutional factors are interacting. Elongation of the ruptured ligaments, proprioceptive deficit, peroneal muscle weakness and subtalar instability are documented aetiological factors of functional instability\textsuperscript{5,6}.

The term functional instability was introduced almost 40 years ago by Freeman as a description of the patient’s subjective complaint of ‘giving way’ He found that proprioceptive deficit was the most important factor behind the development of functional instability. Mechanical instability was less important, and not alone a decisive factor in most cases. It may be concluded that functional instability is caused by mechanical instability, inhibition of proprioceptive function or a combination of these two factors. The specific cause of functional instability in the individual case has to be analysed separately\textsuperscript{19,20,22}.

CHRONIC LIGAMENT INSTABILITY

Chronic lateral ankle joint instability will develop in approximately 10% of patients after acute ligament rupture. This ligament instability, irrespective of its aetiology does not always require surgical reconstruction. The indication for surgical treatment is recurrent ‘giving way’ in spite of proprioceptive training. Non-surgical treatment is therefore always recommended before surgical treatment. Surgical reconstruction is more often needed in athletes with high demands of ankle stability\textsuperscript{10-12}.

More than 50 surgical methods have been published in connection with chronic ankle joint instability. The surgical procedures can be classified as either non-anatomic tenodeses, using tendons around the the ankle joint (e.g. Watson-Jones, Evans and Chrisman-Snook tenodeses) or anatomic reconstruction, with direct suture of the injured ligaments, imbrication and reinsertion to bone, and in some instances augmentation with local tissue e.g. the inferior extensor retinaculum (Gould’s modification of the Broström procedure)\textsuperscript{1-12,16,17,21}.

CLINICAL ASSESSMENT

The diagnosis of chronic ankle joint instability is primarily based on a thorough clinical assessment. The clinical evaluation is based on the anterior drawer sign and the inversion (supination) test. Increased anterior translation of talus in the talocrural joint implies elongation of the ATFL. Increased inversion indicates elongation of the CFL. A combination of ATFL and CFL insufficiency is common\textsuperscript{15,18}.

RADIOGRAPHIC ASSESSMENT

Knowledge of the mechanical stability of the ankle joint both in the sagittal and the frontal plane gives valuable information in the diagnostic assessment of chronic functional instability of the ankle. Standardised stress radiographs can be used both in differential diagnostic evaluation and therapeutic assessment\textsuperscript{13}.

Two radiographic tests can be used, the lateral instability test (Talar Tilt [TT]), (Figure 2) and the anterior instability test (Anterior Talar Translation [ATT]).

Mechanical instability can be defined either as ATT >10 mm or TT >9°. Another way of defining mechanical instability is ATT > 3 mm i.e. the difference in ATT between the functionally unstable ankle and the contralateral ankle and/or TT >3° in patients with unilateral instability. A correlation between functional and mechanical instability has been shown. This correlation is not constant as factors other than mechanical instability can also be responsible for the development of functional instability. Some studies have
thus questioned the reliability of stress radiographs, especially the measurements of TT.

TREATMENT OF CHRONIC ANKLE INSTABILITY

Non-surgical treatment

Of all individuals who have sustained acute ligament injuries, it is probable that less than 10% will need stabilising surgery at a later stage. Before deciding on surgical treatment in a patient with chronic ligament insufficiency, a supervised rehabilitation programme based on peroneal muscle strengthening and co-ordination training should be carried through. Approximately 50% of patients with chronic functional instability of the ankle will regain satisfactory functional stability after 12 weeks on such a programme (Table 1). Patients with high-grade mechanical instability have less chance of regaining satisfactory function by physiotherapy. These patients should undergo surgical treatment.

A stationary bicycle (10 to 15 minutes) can be used to improve blood circulation and for warming-up. Stretching of the calf muscle, with hands pushing against a wall (2x15 seconds) should be performed after each training session.

Surgical treatment

Although numerous different surgical procedures have been described to stabilise the unstable ankle, most of these are minor modifications of: a) tenodeses or b) anatomical reconstructions. Isolated mechanical instability without “giving way” episodes is never an indication for surgical stabilisation of the ankle. It should be emphasised that repeated episodes of giving way do not predispose to osteoarthrosis of the ankle.

Tenodeses have been the most widely used principle of surgical reconstruction. All tenodeses sacrifice normal and in most cases well-functioning anatomical structures, either the peroneus brevis or peroneus longus tendons. Some have used the plantaris tendon, part of the Achilles tendon or even a free fascia lata graft. None of the tenodeses in common use can be considered as anatomical and the result is always altered kinematics and often limitation of joint motion with gradual deterioration of the tenodesis-ligament reconstruction. This might cause degenerative changes of the ankle in the long run. All of these procedures restrict subtalar motion.

The four classic tenodeses are all well-defined and the short- and long-term results well known. They are:
1. Elmslie
2. Evans

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<tr>
<th>Week</th>
<th>Recommended programme</th>
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<tr>
<td>Week 1 to 3</td>
<td>Range-of-motion exercises (flexion, extension, pronation) for increased blood circulation. Cycling using stationary bike.</td>
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<tr>
<td><strong>Week 2 to 12 (general programme)</strong></td>
<td>Training of balance and co-ordination using tilt boards (Figure 4). Foot exercises: Roll a small ball with the foot, back and forth and from side to side. Wrinkle a towel. Pick up marble balls or small rocks. Closed-chain (weight-bearing) exercises. Walking: Walk with variable stride e.g. short steps, long steps, steps with increased flexion of the knee. Walk on tip-toe alternating with heel-walking. Jog on a soft mattress. Walk with a rubber cord around the ankles. Heel-raising (bilateral).</td>
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<tr>
<td>Week 2 to 5</td>
<td>Endurance and strength training: Isometric contractions in flexion, extension and pronation. Use a rubber cord and a weight-shoe. Train dorsiflexors, plantarflexors and pronators. For endurance training use a rubber cord and do at least 20 to 30 repetitions 3 or 4× at each training session.</td>
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<tr>
<td>Week 5 to 7</td>
<td>Increase the training by shortening the rubber cord and by using a weight-shoe.</td>
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<td>Week 7 to 10</td>
<td>Heel-raises standing on one leg. Step-ups on a box. Step-ups using two boxes. Jog up and down and from side to side. Increase the weight of the weight-shoe for heavy weight training. It is important to train the pronators to achieve increased postural control and reflex training (shorten the reaction time of the peroneal muscles).</td>
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<td>Week 10 to 12</td>
<td>Individual sports activity and team training.</td>
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Table 1: Suggested supervised rehabilitation programme based on peroneal muscle strengthening and co-ordination training.
Several authors have reported satisfactory functional results after anatomical reconstruction. The surgical technique described by Karlsson et al is technically simple\textsuperscript{10,11,21}. The damaged and/or elongated remnants of the ATFL and CFL are transected, shortened 2 to 5 mm, imbricated and reinserted into bone. Satisfactory functional results have been reported in approximately 90\% of the patients, also with roentgenographic evidence of improved mechanical stability. The results were less satisfactory in patients with generalised hypermobility of the joints, very long-standing ligamentous insufficiency (over 10 years) and in patients who had had previous ligament surgery of the ankle joint. These patients should probably be treated with tenodesis. After surgery, early range of motion training using a walking boot or Air-Stirrup\textsuperscript{®} ankle brace can be safely employed without any risk of compromising the mechanical stability of the reconstructed ankle. Full weight-bearing is allowed.

Anatomical reconstruction has been shown to be technically simple with very few complications, giving satisfactory functional results both in the short- and the long-term\textsuperscript{12,13}. Mechanical stability has also been shown to be satisfactory, correlating well with the functional results.

References
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Figure 3: The ligaments are now reconstructed by shortening and tightening. The sutures are pulled through drill holes in fibula and tied over bone bridges.

Figure 4: The final step of the operation is duplication, using the periosteal flap and the proximal part of the ligaments.