Management of lateral ankle injuries

A multidimensional approach

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General introduction
An ankle sprain is a common injury caused by a traumatic inversion of the foot. The term ‘ankle sprain’ often refers to a lateral ankle sprain. If treated inadequately, patients may subsequently develop chronic ankle instability. Hence, these injuries often receive minimal medical attention.

Patients who do not fully recover after sustaining a lateral ankle sprain and suffer from persistent complaints such as chronic instability may benefit from professional treatment to minimise disability. Reassessment of current practice will endorse improvement in the management of lateral ankle sprains and chronic ankle instability. In turn, best practise will optimise recovery times and prevent residual complaints in patients who sustained a sprain.

**Aetiology of lateral ankle sprains**

The ankle consists of multiple joints, being the tibiotalar joint, the tibiofibular (syndesmotic) joint and the talocalcaneal (subtalar) joint. The tibiotalar and syndesmotic joint are also described by the term talocrural joint as the tibia, talus and fibula are all involved in this same joint and its motion. For healthy individuals the talocrural joint is mainly responsible for dorsiflexion and plantar flexion, whereas the subtalar joint allows inversion and eversion of the foot.

The talocrural and subtalar joint are stabilised through passive and active mechanisms. Passive mechanisms include joint geometry, the lateral ankle ligaments (anterior talofibular ligament – ATFL, posterior talofibular ligament – PTFL and the calcaneofibular ligament – CFL) and the medial ankle ligaments (deltoid ligament complex). Active stabilisation is achieved by means of neuromuscular mechanisms such as balance, coordination, muscle activation and reaction time, muscle strength and proprioception. Inability to actively or passively maintain joint stability may result in either a lateral ankle sprain or a medial ankle sprain (eversion-external rotation trauma), which may lead to deltoid ligament injury. Compared to lateral sprains, injury of deltoid ligament complex is relatively rare. Despite the lower incidence, the consequences of deltoid ligament injury should not be underestimated. A medial ankle sprain is more complex and often related to fractures. Although both injuries find resemblance in the term ‘sprain’, a medial sprain greatly differs from a lateral sprain in both trauma mechanism and potential impact. The potential consequences of a medial sprain highlights the importance of adequate treatment. For this thesis, the high incidence in combination with the underestimated functional consequences formed the motivation to focus the included studies on lateral ankle sprains.

During history taking, patients who sustained a lateral sprain mostly describe an inversion-plantar flexion trauma with subsequent pain on the lateral side of the ankle. The inversion-plantar flexion trauma primarily stresses the ATFL and secondly the CFL, thereby resulting in overstretched ligaments, micro-lesions or ruptured ligaments. If the stress exceeds the maximum load capacity of the ligaments it causes a partial or full rupture. If the ligaments undergo insufficient healing this leads to abnormal laxity of the ligaments, subsequently leading to instability of the talocrural joint and predisposing patients to subluxation of this ankle joint. This is
often described by patients as the feeling of giving-way or instability of the ankle joint. In ankle kinematics this instability is represented as an increase of the inversion motion and axial rotation in the talocrural joint. Knowledge of the trauma mechanism underlying a lateral ankle sprain is important since lateral sprains have been reported as the most common musculoskeletal injury in both the general and athletic population. These injuries lead to functional disability and may even result in athletes abandoning their sport in fear of recurrent sprains. The highest incidence is seen in the age category of 15-24 years old. Sprains are also more frequently seen in men than in women. Athletes that practice sports such as volleyball, basketball, handball, football and running are especially at risk. In these sports, the activities that increase the risk of sustaining an ankle sprain, such as landing, cutting and twisting, running, jumping and player contact, are frequently performed.

Even though an ankle inversion-plantar flexion trauma is a frequently seen injury, the potential consequences of such an injury are still underestimated. The majority of patients who sustain a lateral ankle sprain do not seek professional care in the acute phase. In those who eventually seek treatment, up to 72% of patients may experience persistent complaints such as pain, swelling, sensorimotor deficits and (the feeling of) giving-way and 34-70% of patients report recurrent sprains.

**Diagnostic roadmap**

Directly after sustaining an ankle sprain evaluation of the extent of the injured tissue is key to ensure a patient receives the best treatment. Excluding osseous injury is a priority as 5-20% of patients have a concomitant fracture after sustaining a lateral ankle sprain. The likelihood of a fracture is assessed through application of the Ottawa Ankle Rules (OAR). The OAR have demonstrated excellent reliability and a high sensitivity (97%) to diagnose ankle fractures, but a low specificity (37%) in patients who sustained a sprain. Due to the high number of false-positive results a radiograph is required when the OAR are positive to rule out fractures and other osseous injuries.

After ruling out a fracture, physical examination should be continued by testing for pain, swelling, stability, strength, proprioception and sensation. In the acute phase, pain may be so severe that a detailed physical examination cannot be (reliably) performed. Delayed physical examination, about 4 to 5 days after the initial trauma has been shown to be highly sensitive (96%) and reasonably specific (84%) for indicating ankle ligament lesions as it allows the pain and swelling to lessen. Delayed physical examination is therefore more suitable than physical examination directly post-trauma to diagnose the extent of the ligaments injury, this is the diagnostic tool of choice in the acute setting.

Based on the findings during physical examination, ankle sprains can be classified as ligament injuries with or without the presence of ankle ligament laxity. A sprain is characterised by lengthening or microscopic rupture of the lateral ankle ligaments due to stretching beyond capacity, symptoms of mild tenderness and swelling of the
ankle without laxity of the ankle joint (negative anterior drawer test). Patients with a lateral ankle ligament rupture (8-18%) report symptoms of severe tenderness and swelling of the ankle and severe laxity of the ankle joint (positive anterior drawer test)\(^{418}\).

Diagnostic imaging, such as ultrasonography (US) may be beneficial to diagnose the extent of the soft tissue injury, in addition to physical examination. In multiple study settings US has shown a high sensitivity (92%) and moderate specificity (64%) to diagnose injury of the ankle ligaments and other soft tissue damage. In addition to the capability to diagnose soft tissue injury, US is widely available and not associated with high cost. A CT-scan and an MRI-scan can be also be used in the acute setting, though their value can be argued. The use of a CT-scan and an MRI-scan is associated with high costs compared to radiographs and US. Although there is an increasing availability of imaging techniques and costs are decreasing, use should be limited in the acute setting to clinical suspicion of concomitant injury, such as a fully ruptured ligament or an osteochondral defect (OCD)\(^{207, 224, 303}\). Delayed physical examination performed 4 to 5 days after the initial trauma, therefore, is the diagnostic test of choice.

**Initial treatment**

Management of ankle sprains can be challenging, especially in the athletic population because of the high sport-specific loading conditions of the ankle joint in combination with an urgency to quickly return to performance. The two treatment options include functional (i.e. non-surgical) and surgical treatment\(^{223}\). As in the majority of patients (up to 85%) functional treatment is successful, and ankle surgery is more invasive, functional treatment is preferred in the general population after sustaining an initial ankle sprain\(^{377, 429}\). Functional treatment, including immobilisation for a short period (<10 days), functional support and exercise therapy, may reduce swelling and improve compensation mechanisms that help maintain joint stability\(^{215, 222, 413}\). Ankle laxity is often left untreated, predisposing patients to recurrent sprains. Acute surgical stabilisation (<6 months) is mainly reserved for the high demanding (professional) athletes who require a better objective stability due to higher loading conditions, and strive for a quick return to play\(^{216, 264, 303, 377}\). The treatment choice should based the combination of patient specific preferences\(^{368}\) and injury severity\(^{440}\).

**Measuring effectiveness**

Evaluation of a rehabilitation program may indicate whether the program has been effective or not and whether adjustment of the treatment strategy is required. Important aspects of this evaluation are recovery of function, return to play and re-injuries. For the purpose of the evaluation of treatment effectiveness, patient reported outcome measures (PROMs) and function tests can be utilised. The PROMs are questionnaires used in the appraisal of the day-to-day management of patients and to indicate readiness to return to play. Additionally PROMs can be used in research to compare current standards with new treatment options\(^{59}\). To ensure that PROMs
can be used for these purposes, a set of easy to use and accessible tools is required. Preferably these can be used on a daily basis, without any additional requirements and at low cost. Tools used for these purposes need to be valid and reliable. In addition to quantifying the effect of the injury or disability on function, recovery of function needs to be measured.

There are multiple PROMs that were developed to evaluate complaints of the foot and ankle. The most commonly used PROMs are the Foot and Ankle Outcome Score (FAOS), the Foot and Ankle Ability Measure (FAAM), and the American Orthopaedic Foot and Ankle Society (AOFAS) scale. These PROMs are used to assess pain, stiffness, swelling, limitations in activities of daily living (ADL), quality of life (QoL), and limitations in sports. To specifically assess QoL, the ShortForm-36 (SF-36) can be used. This questionnaire may be preferred over the ShortForm-12 (SF-12) and EuroQol-5D (EQ-5D) as the SF-36 assesses the different aspects of QoL more extensively and provides a separate score for physical and mental health.

In patients who have sustained a sprain, it may not always be easy to choose the right tool to assess the consequences of the injury and objectify complaints. Most symptom-focused and disability-focused questionnaires are not fit for patients who sustained a lateral sprain or suffer from ankle instability as their major complaint is recurrence of lateral ankle sprains, often without any ankle complaints in between recurrent injuries. After the acute phase of a lateral ankle sprain, when the swelling and pain are gone, most patients do not report any residual symptoms or a lower than normal QoL, causing a ceiling effect that limits the interpretation of PROM scores. Even if patients suffer from pain or swelling to some degree and possibly report the subjective feeling of giving way, they rarely report limitations in ADL or sports. In patients that objectively suffer from limitations in ADL or sports, underreporting may be a result from coping mechanisms patients developed after sustaining recurrent ankle sprains. Patients will rather avoid activities they fear than expose themselves to activities that increase the risk of recurrent ankle sprains. This leads to a gradual decrease of activity level, almost unnoticed by patients unless this is explicitly pointed out.

Use of PROMs that specifically focus on these aspects of recovery after an ankle sprain may avoid the floor or ceiling effect, enabling not only an evaluation at baseline, but also better assessment of recovery than aforementioned PROMs. Of the PROMs currently used in the Netherlands, the FAOS has been validated in a population with ankle sprains and ankle instability. The FAOS, however, does not contain any questions regarding recurrent ankle sprains, which is the major complaint in most patients. For this reason, questionnaires (e.g. the Cumberland Ankle Instability Tool (CAIT)) were developed that include items to evaluate ankle inversion sprains and inversion instability (e.g. frequency, severity, spontaneous recovery). This tool may provide a more valid answer to the question whether and to what degree treatment is effective according to patients.
Prevention of new injuries: who is at risk?

After sustaining an initial lateral ankle sprain, patients have a high risk of recurrent sprains (3-34%)\(^4^{28}\). Up to 53% of patients report residual symptoms such as pain, swelling, or the feeling of giving way two years after sustaining an ankle sprain\(^4^{28}\). To avoid recurrent sprains and long-lasting complaints, secondary prevention programs are required. These programs should focus on the training of compensation mechanisms through neuromuscular control, or focus on addressing risk factors and negative prognostic factors in order to avoid future sprains and complaints (Box 1.1).

Differentiation between risk factors and negative prognostic factors is difficult. Both risk factors and negative prognostic factors may be the target of secondary prevention programs. The risk factors that lead to the initial ankle sprain may also increase the risk at sustaining recurrent sprains if they remain untreated. Negative prognostic factors in turn lead to persistent complaints such as pain, swelling and giving way resulting in chronic ankle instability, and positive prognostic factors facilitate recovery.

The factors that contribute to an increased risk of sustaining (recurrent) ankle sprains may vary from an ankle sprain in history\(^2^{81}\) and type of sports practised\(^2^{81}, 4^{01}, 4^{37}\), to ligament laxity\(^1^{92}, 1^{93}\) and impaired balance\(^7^{8}\). Some of these risk and prognostic factors can be identified through history taking (e.g. previous injuries, sports level), physical examination (e.g. ROM, ligament laxity)\(^1^{29}, 2^{93}, 3^{47}, 3^{91}\) or diagnostic imaging (e.g. ligament length, ankle alignment)\(^2^{07}, 2^{16}, 2^{24}, 3^{03}, 4^{05}\). On most variables there is still an ongoing discussion regarding their exact role in sustaining (recurrent) ankle sprains\(^2^{23}\). The fact that ligament laxity is not per se related to the degree of disability reported by patients supports the hypothesis that not all patients suffer from complaints after sustaining a lateral ankle sprain, but that complaints are rather the result of an interaction between multiple variables\(^8^{7}\). Job demands, sports level, functioning and compensation mechanisms may play an important role in the risk of sustaining recurrent ankle sprains\(^2^{24}\). Identification of these risk factors and the interaction between variables may help identify points of intervention to improve treatment of these patients and, with that, treatment outcome.

What if functional treatment fails?

Despite high recovery rates, functional treatment does not guarantee resolution of symptoms. Those who experience persisting (feeling of) giving way of the ankle

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**Box 1.1 Risk factor versus prognostic factor\(^4^{2}\)**

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<th>Risk factor</th>
<th>Prognostic factor</th>
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<td>Factors that increase the risk of sustaining an initial or recurrent ankle sprain. Risk factors additionally function as negative prognostic factors.</td>
<td>Factors that positively or negatively affect the course of recovery after sustaining an initial lateral ankle sprain.</td>
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joint with or without symptoms of pain, swelling, ligament laxity and/or sensorimotor deficits for at least twelve months are defined as suffering from chronic instability\textsuperscript{90, 142, 145}. This condition often leads to progressive limitations in ADL, work and/or sports\textsuperscript{142}. After sustaining an initial sprain about 10-53\% of patients are at risk of progressing to chronic ankle instability\textsuperscript{264, 428}. When secondary prevention after sustaining an initial lateral ankle sprain has failed, early identification and treatment of chronic instability is important as recurrent sprains may lead to intra-articular damage, risking progressive disability\textsuperscript{259, 328}. For this reason, when patients have progressed to chronic instability after sustaining an ankle sprain, adequate diagnosis and treatment in this phase is essential to resolve complaints and to avoid or further reduce progression of disability and concomitant joint damage.

Similar to the diagnostic phase after an initial sprain, history taking is important to determine the degree of disability experienced during activity, and physical examination is necessary to assess locations of (focal) pain, swelling, and joint laxity\textsuperscript{218, 252}. For chronic ankle sprains, US may be used to determine the extent of the ligamentous damage (e.g. lengthening or absence due to rupture) and concomitant soft tissue injury\textsuperscript{185}. An MRI-scan may also be used to assess ligamentous damage, containing the ability to differentiate between an overstretched ligament, solely visualising local oedema, and a total ligament rupture\textsuperscript{5}. Additionally an MRI may be indicated when there is a high suspicion of other soft tissue injury such as peroneal muscle or tendon damage\textsuperscript{207}. To evaluate potential intra-articular damage and to perform preoperative planning (e.g. in case of a concomitant OCD) a CT-scan may be indicated\textsuperscript{207}.

Functional limitations may be an indication for surgical treatment with the aim to eliminate laxity of the ankle joint. Surgical procedures available for this purpose are non-anatomic and anatomic ligament reconstruction\textsuperscript{124}. Non-anatomic procedures include tenodesis reconstruction, using tendons to stabilise the ankle joint and is not restricted by original anatomic structures\textsuperscript{124}. Anatomic reconstruction can also be performed, using tendon tissue to stabilise the ankle or repair of the original ligamentous tissue, both with the aim to maintain normal ankle joint anatomy, placing the origin and insertion of the reconstructed or repaired tissue on the ATFL footprints\textsuperscript{154}. The risk of complications when choosing for surgery, make healthcare professionals initially prefer functional treatment to surgical stabilisation\textsuperscript{223, 440}. In patients that suffer from chronic ankle instability functional treatment may include neuromuscular training, muscle strengthening exercises and the use of a brace. When patients still suffer from recurrent sprains after six months, despite adequate supervised neuromuscular training and functional support, surgery is often the treatment of choice\textsuperscript{143}.

Overall, surgical stabilisation provides good functional outcome in terms of a reduction of symptoms and return to work and sports\textsuperscript{152}. Reports indicate low complication and recurrence rates. The stabilising effect of surgery, however, may deteriorate over time. Especially in patients who sustained a more severe initial ankle sprain (i.e. rupture of the lateral ligaments), the incidence of recurrent sprains can be
as high as 39% measured 6.5 years after stabilisation surgery. Although anatomic procedures are thought to be superior, a clear comparison between alternative techniques is still missing.

Summarising ankle joint instability is more complex than a simple sprain with the subsequent presence of lateral ligament laxity. Patients who sustained an initial ankle sprain are in need of adequate treatment to resolve complaints, subsequent prevention of recurrent ankle sprains, and progression to chronic ankle joint instability. The multitude of treatment options and potential risk factors for recurrent injury require an overview with recommendations to structure the road to recovery for a patient who sustained an initial lateral ankle sprain. Potential opportunities for intervention in this specific care-pathway include: (1) acute surgery followed by rehabilitation; (2) functional treatment, followed by secondary prevention; and (3) in patients who sustain recurrent ankle sprains despite secondary prevention programs, again initiation of functional treatment, if ineffective followed by surgical stabilisation and rehabilitation (Figure 1.1). The purpose of the studies included in this thesis is to form new evidence-based recommendations on the best diagnostic modalities, treatment strategies and secondary prevention strategies in patients who sustained a lateral ankle sprain to minimise complaints, and to facilitate optimal recovery and return to activity.

Aim and outline of this thesis

Patients desire fast recovery with quick return to work and sport and without secondary sequelae. To support this objective and to enable optimisation there is a need of continuous evaluation of management strategies. Therefore this thesis aims to contribute to the improvement of diagnosis, treatment and secondary prevention for patients that sustained a lateral ankle sprain.

Part I of this thesis describes an updated overview of the current diagnostic modalities as well as the current treatment and preventive strategies for lateral ankle sprains. Reliability and validity of diagnostic and evaluation tools are studied to enable diagnostic decision making and treatment evaluation. In Part II an overview is given of potential risk factors that may help identify a patient at risk of sustaining recurrent ankle sprains. The purpose is to provide data for the development of a risk assessment model. This model will help to individualise management, help the prevention of recurrent ankle sprains and development of chronic ankle joint instability. Part III describes an overview and outcome comparison of different surgical treatment options used for surgical stabilisation of the ankle. It concludes on an advice on the best surgical treatment in regard to treatment of chronic lateral ankle joint instability. Part IV finalises this thesis by means of a discussion and a summary of its contents.

Part I – Recommendations to improve current practice

After publication of a guideline published in 2012, many studies have been published on the management of lateral ankle sprains. The objective of Chapter 2...
is therefore to implement the results of the recent literature and to provide updated recommendations regarding diagnostics, treatment and prevention in the guideline on lateral ankle sprains.

Bone morphology, including hindfoot alignment, has been described as a probable risk factor for sustaining a lateral ankle sprain. The measurement of hindfoot alignment on an ankle radiograph is often not made a 100% perpendicular to the talocrural joint, despite its validation in this position. A varying projection angle may affect the reliability of findings on an ankle radiograph. Chapter 3 studies the effect of a varying projection angle in measurement of hindfoot alignment and defined a ‘safe zone’ that does not affect measurement outcome.

Important in the management of lateral ankle sprains is treatment evaluation using a validated patient reported outcome measure (PROM). For the ankle a number of PROMs are available in Dutch, but none specifically focuses on ankle sprains or instability. The Cumberland Ankle Instability Tool (CAIT) that was designed for this particular purpose is not translated into Dutch and not validated. For this reason Chapter 4 entails the validation and reliability assessment of this PROM.

Part II – Prognosis and prevention: who is at risk?

Ideally patients at risk of chronic lateral ankle joint instability should be identified prior to developing instability to avoid long lasting complaints and limitations in ADL and sports. With the objective of creating a risk assessment model to identify patients at risk Chapter 5 provides an overview of current potential risk factors and prognostic factors for (recurrent) lateral ankle sprains. Chapter 6 outlines the methods for a risk assessment model to identify patients at risk of chronic instability. Chapter 7 includes reliability assessment of three radiographic parameters that can potentially be included in the risk assessment model.

Part III – Surgical treatment of the unstable ankle

After functional methods have failed, surgical treatment can be an option in patients who suffer from chronic lateral ankle joint instability. Although it is hypothesised that anatomic ligament reconstruction techniques provide superior results compared to non-anatomic stabilisation procedures, a comparison of the outcomes of different surgical options is missing. Therefore the objective of Chapter 8 was to assess which stabilisation methods are used and which provides the best functional outcome. An alternative to surgical reconstruction and stabilisation is an arthroscopically performed capsular shrinkage technique. Chapter 9 describes the long-term results of this technique and compares these results with the long-term results of the reconstruction and stabilisation techniques.

Part IV – General discussion and summary

Chapter 10 contains the general discussion of this thesis and Chapter 11 includes the English summary.
Figure 1.1 Potential care-pathways for patients that sustained a lateral ankle sprain. This timeline can be expanded with events that break into the timeline such as a recurrent sprain or initiation of a high demanding sport. The dark blue boxes include topics covered by this thesis.