Management of lateral ankle injuries

A multidimensional approach

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General discussion
Lateral ankle sprains are of a multifactorial nature. The number of factors that contribute to sustaining an ankle sprain also lead to a high risk of recurrence. The studies included in this thesis have evaluated the diagnostic pathways, treatment strategies and prevention programs (Figure 10.1). Through this multidimensional assessment, the research objective of the studies is to improve the care-pathway (including diagnostics, treatment and prevention) of patients who sustained a first-time lateral ankle sprain. Identification of risk factors by healthcare professionals provides indicators for treatment and prevention, with the aim to increase efficiency of the management of this commonly seen injury, and improve subsequent treatment outcome.

Part I – Recommendations to improve current practice

An ankle sprain is too often regarded as a simple ankle trauma that rarely requires medical attention. A significant number of patients will not recover well without professional treatment. The high incidence of lateral ankle sprains in combination with subsequent functional disabilities supports the need of adequate diagnosis, treatment and prevention\textsuperscript{142}.

Even though a lateral ankle sprain is a common injury, the consequences of inadequate diagnosis and management are underestimated. In all patients who seek professional care after sustaining an ankle sprain, injury assessment through physical examination and on indication diagnostic imaging are essential. The main objective is to evaluate the severity of the injury of both the primary lesion and potential secondary damage, such as osteochondral defects (OCDs), to provide subsequent directions for treatment\textsuperscript{443}. In the acute phase, patients will mainly report pain and swelling of the ankle joint and limited joint function\textsuperscript{70, 182} leading to work and sport absenteeism\textsuperscript{443}. In these patients management will focus on functional treatment using a stepwise rehabilitation plan to promote quick return to activity. If this approach is ineffective, patients will report recurrent lateral ankle sprains in addition to pain and limitations in activity. The risk of developing intra-articular pathology will increase with every recurrent sprain\textsuperscript{382}. In case of persistent complaints and avoid recurrent sprains, and subsequently reduce the risk of more severe pathology, surgical treatment options may be considered. An update of evidence on the optimal management of acute sprains is necessary to improve treatment and to avoid a cascade of progressive limitations of activities of daily living (ADL), sports and work in those who sustained a lateral ankle sprain\textsuperscript{382}.

An update of the clinical guideline on diagnosis and treatment of acute ankle sprains is reported in Chapter 2. In the guideline the use of radiographic imaging is recommended to rule out a fracture and subsequent physical examination is recommended to assess the severity of ligament injury. Thereafter a treatment plan can be defined, including use of a functional support and exercise therapy. Injury prevention, also by functional support, needs to be in the treatment plan too, providing extra support for patient during work or sport. In addition to these recommendations, risk factors and prognostic factors should be assessed to increase effectiveness of
treatment and prevention. In addition to providing the best treatment outcome for patients, functional therapy, including the combination of exercise therapy and brace use, has also demonstrated to be more cost-effective compared to other treatment and preventive modalities, without limiting sport-specific performance. Despite existing recommendations, a small proportion of patients who visit the emergency room (ER) after sustaining an initial lateral ankle sprain (without a concomitant fracture) still receive a lower leg cast to treat pain. Immobilisation for longer than ten days is not recommended as treatment in patients who sustained an ankle sprain as it is associated with inferior outcome compared to functional support in terms of range of motion (ROM), patient satisfaction and functional recovery. After cast removal, patients do not always receive an advice regarding further treatment options such as physical therapy or the prophylactic brace use. This outlines the need of exposure of the recommendations provided by the updated guideline on ankle sprains. Patients will benefit from compliance with these recommendations and improve patient recovery by indicating proper treatment. Providing these management strategies, that have proven good long-term results, will also lower the number of patients suffering from persistent complaints and recurrent lateral ankle sprains.

At the ER a non-weight bearing radiograph is made to exclude a fracture after sustaining a lateral ankle sprain. This radiograph may also be used to assess bone and ankle joint geometry, which has been indicated as a potential prognostic factor for developing chronic ankle joint instability. For patient-related or logistical reasons the radiographs made at the ER are often not perpendicular or parallel to the talocrural joint. In order to determine the effect of varying foot positions on reliability of radiographic measurements we performed a study to assess the effect of foot rotation on measurement of hindfoot alignment in Chapter 3. Based on alignment measurements on digitally reconstructed radiographs we concluded that reliability is reduced when foot rotation exceeds 10° of internal rotation or 10° of external rotation. Not only foot rotation should be limited to ensure reliable assessment of hindfoot alignment. Previous studies also showed dorsiflexion and plantarflexion affect these radiographic measurements. Our results underline comparable findings in literature, confirming that a variation in projection angle can be forgiving to some degree (5°-10°), but awareness of its effect on measurement validity and reliability is essential. Restricting the foot rotation enables reliable measurement of risk factors related to bone and ankle joint geometry, and consecutive decision whether surgical correction is required to avoid recurrent sprains. The use of CT-imaging can solve the issue by offering three-dimensional image reconstruction. This is, however, not a preferred method due to the minimal effect on treatment decision compared to standard radiographic assessment and associated costs.

Imaging at the ER is often limited to the use of radiographs only. Recent studies have shown that ultrasonography (US) provides a reliable indication of the degree of ligament damage in patients who sustained a lateral ankle sprain. Based on findings of these studies, it may serve to help indicate the type of treatment required. The potential clinical value of US application, availability at the ER and relatively
low associated costs, form arguments to implement US-assessment at the ER in patients who sustained a lateral ankle sprain. For such a purpose, however, first an easy to use classification needs to be developed. Subsequently matching specific recommendations need to be formulated for the treatment strategy per subcategory of ligament injury, providing opportunity to improve patient recovery. The original classification of lateral ankle ligament injury differentiates grade 0 (no ATFL injury), grade I (overstretching/micro-rupture of the ATFL), grade II (partial rupture of the ATFL) and grade III (total rupture of the ATFL), leaving room for interpretation. Our recommendation would be to classify the injury into two categories: ‘intact ATFL’ (grade 0 and I) or ‘complete rupture of the ATFL (grade II and III).

Different treatment strategies can be chosen based on the extent of the ligament injury, concomitant injuries occupation etc. Functional treatment is preferred. To assess whether the chosen treatment is effective on reported symptoms, and whether a patient experiences functional recovery, patient reported outcome measures (PROMs) can be used. The Cumberland Ankle Instability Tool (CAIT) is such a tool, but was not yet available in Dutch. For this reason, we decided to translate and validate the CAIT in the Dutch population that visits the outpatient clinic (Chapter 4). Based on our findings we concluded that the CAIT can reliably be used to assess the degree of functional disability after sustaining a lateral ankle sprain, to assess treatment effectiveness and also to evaluate whether a new approach is required in case of unsatisfying results. In contrast to the Foot and Ankle Outcome Score (FAOS), the CAIT only assesses pain and sprain related events, but disregards other symptoms such as swelling or limitations in ADL. However, the FAOS does not contain the ability to assess specific sprain related events, which are present in our population of interest, and are not always accompanied by other concomitant complaints. For this reason, it may be argued the CAIT and FAOS can best be combined in patients who sustained a lateral ankle sprain to provide a complete and reliable evaluation of both sprain related events and secondary complaints if present.

Questionnaires such as the CAIT and the FAOS seem ideal tools to objectively assess injury severity, limitations in ADL and to evaluate treatment effects. However, PROMs have been validated in the literate population with the requirement that patients are able to fill out the questionnaires independently. Despite careful formulation of questions, for too many patients in the general population the questions in PROM questionnaires are incomprehensible. When leaving room for subjective interpretation of the questions, a PROM will measure health literacy rather than evaluate complaints. This is important to consider when interpreting the PROM scores, especially when used in the low-literate and illiterate patients. Despite its current educational system, the Netherlands still has about 1.3 million inhabitants that are low-literate and about 250,000 inhabitants that are illiterate. Format changes such as more white space, larger font size, a private setting to fill out the questionnaire together with relatives and the use of images can be considered. These measures may benefit patients when filling out PROMs and prevent inequality in healthcare through the use of PROMs.
Increasing awareness of recommendations provided by the updated guideline through implementation in local protocols and updating PROMs to ensure reliable use in the full population will improve the care for patients who sustained a lateral ankle sprain. Our most important recommendation in the updated guideline, which still requires implementation in clinical practice, is the assessment of potential risk factors for recurrent sprains. Identification of risk factors not only provides opportunity to identify patients at risk of persisting complaints who require further treatment and follow-up, but additionally provides points of intervention for treatment and prevention programs.

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

Despite adequate treatment, a specific patient group may be at risk of recurrent ankle sprains and, on the long term, develop chronic lateral ankle joint instability\(^{428}\). To prevent recurrent sprains, and potential concomitant joint damage, secondary prevention strategies are required\(^ {382} \). These strategies may range from including a warming-up prior to the sport activity\(^ {241} \), balance exercises and proprioception exercises\(^ {443} \), to the use of ankle support, such as brace or tape\(^ {477} \). Prevention strategies by means of an ankle brace have shown to decrease both the incidence and severity of ankle sprains through restriction of ROM\(^ {438} \). Beneficial restrictive properties on joint motion, however, are lost after 45 minutes of exercise in case of a brace and after 20 minutes of exercise in case of tape\(^ {477} \). Despite the loss of restrictive effects, braces have not only shown to be superior compared to tape (in both preventive effect and comfort)\(^ {195} \), but also compared to a neuromuscular (balance board) training program\(^ {205} \).

In patients who sustained a lateral ankle sprain, prevention cannot be limited to functional support and exercise only in order to optimise treatment outcome for patients. Risk factors and prognostic factors may also be the target of prevention strategies\(^ {443} \). When considering these factors, differentiation can be made between modifiable and non-modifiable factors, as solely modifiable factors may be target of treatment and prevention strategies\(^ {443} \). The great number of studied potential risk factors was the reason to create an overview of these targets through a systematic search of publications and meta-analyses of the reported data (Chapter 5). Our overview included a total of 80 relevant studies. Variables such as a history of ankle sprains\(^ {25, 77, 294} \), body height\(^ {129, 294} \), and neuromuscular control deficits\(^ {132, 190, 466} \), have been reported as risk factors for (recurrent) ankle sprains and chronic ankle joint instability. Despite the extensive number of studies on risk and prognosis, we only found consensus on a higher BMI, a higher weight, and stability deficits as risk factors through our meta-analyses. These three modifiable risk factors can be targeted during prevention programs to further decrease the risk of recurrent sprains. The use of meta-analyses provided a greater weight to our study than those previously performed. However, the overall low number of included patients resulted in a lack of power regarding the relation of studied variables (e.g. body height, bone geometry) with ankle sprains and chronic ankle joint instability\(^ {309} \).
To further investigate the exact role and extent of the contributed effect of risk factors on sustaining recurrent lateral ankle sprains or developing chronic ankle joint instability, we designed a risk assessment model (Chapter 6). This model will help to identify present risk factors that need to be addressed, in addition to matching clinical consequences to the model output to facilitate adequate treatment decision and outcome for patients. Based on literature different approaches can be identified that are used to design such a model\(^80,134,217\). One is to include all known risk factors into a checklist without assigning a weight per variable, thereby indicating only a relative risk of a recurrent lateral ankle sprain or chronic ankle joint instability based on the number of risk factors present in a patient. A second approach is to assign a weighted score per risk factor based on the input from international experts\(^390\). A third approach, which provides the most reliable results, requires the following conditions: (1) variables are selected systematically, (2) sufficient events per variable are included to minimise bias in regression coefficients\(^309\), (3) reliable measurements are chosen, (4) internal and external validation is assessed\(^374\). To ensure clinical implementation of this model, it needs to be easily applicable in the ER setting. This means the model ideally does not require additional measurements, than those already collected at the ER, claims no extra costs or time. Input is therefore limited to patient characteristics, non-weight bearing radiographic imaging and physical examination. Ultimately, such a risk assessment tool could function as a clinical decision-making tool, indicating which treatment is required.

Bone geometric variables that have been reported as potential risk factors for developing chronic ankle joint instability are ankle alignment\(^405\), fibular position\(^31,189\) and tibiotalar congruency\(^131\). These variables are an example of potential indicators for the need of surgical treatment. As these are not affected by functional therapy, non-surgical treatment will not reduce the risk of chronic ankle joint instability. Before implementation in a risk assessment model, reliable measurement of variables needs to be established. Therefore, we decided to assess the inter- and intra-observer reliability of these three radiographic parameters, not only for radiology residents, but also for an orthopaedic resident and an ER physician, as these are all involved in the diagnostic process of patients who sustained an ankle sprain (Chapter 7). Reliability assessment of these variables indicated that only measurement of the fibular position and tibiotalar congruency were sufficiently reliable to be directly included in our risk assessment model. Ankle alignment, quantified by the medial distal tibial angle (MDTA), could not be reliably measured. This finding does not correspond with previous studies, which reported good to excellent reliability for MDTA measurement\(^23,378\). The low reliability may have been caused by the imaging method used. The MDTA has been validated on an anteroposterior (AP) lower leg radiograph visualising a large proportion of tibia. For this study the mortise view was used, which is the imaging standard at the ER, only visualising the distal part of the tibia. Additionally the MDTA is affected by both axial rotation and the horizontal projection angle\(^22,23\), which may affect imaging made in the ER setting due to a high workload. Alignment measurement can still be considered as a potential parameter in
the risk assessment model of chronic ankle joint instability. Preferably an alternative measurement method than the MDTA is sought, or an AP lower leg view instead of a mortise view can be considered.

Currently, acute surgical repair is often reserved for professional athletes. In some cases, non-professional athletes may also require surgical stabilisation in order to prevent the development of chronic ankle instability. A reliable and valid risk assessment model will help identify these patients and provide on-time and adequate treatment. Clinical implementation of the model will prevent patients from suffering of progressive limitations in ADL and sports, as well as lower the risk of concomitant joint damage as a result of sustaining recurrent sprains. Identification of individual risk factors in patients may also help to indicate the required treatment such as balance exercises, or the need for early surgical stabilisation.

Part III – Surgical treatment of the unstable ankle

If a patient progresses to chronic ankle joint instability, suffering from persistent giving way for at least twelve months, with insufficient results of functional treatment, surgery may provide a solution to relieve symptoms. The choice of surgical stabilisation is based on careful consideration as it is associated with a risk of complications without a guarantee that complaints will be fully resolved or that the chronic ankle joint instability will not recur.

To define which surgical stabilisation method provides the best functional outcome for patients we performed a systematic review in Chapter 8. Our comparison of available techniques based on PROMs indicated that techniques respecting the original ankle anatomy by means of performing an anatomic reconstruction or an anatomic repair, provide the best functional recovery. Although anatomic reconstruction was found to be superior to anatomic repair, the reconstruction technique has been reported as more invasive. Anatomic reconstruction requires deeper drill-holes and (autologous) tendon tissue as opposed to smaller drill holes, and no necessity of a graft for the repair technique. Reports in literature are inconclusive to whether either technique is associated with a greater risk of recurrent sprains. Non-anatomic procedures, such as tenodesis surgery, have shown to provide the lowest functional outcome in combination with the highest risk of postoperative complications (e.g. drill-hole fractures, wound infections and ROM restriction). To ensure optimal treatment of patients who suffer from chronic ankle joint instability, surgical treatment should therefore focus on preserving the original anatomic state through anatomic reconstruction or anatomic repair. We recommend to limit the use of non-anatomic reconstruction to the purpose of salvage only if there are no other options.

Patients preferably seek a treatment that will help resolve complaints, without the risk of recurrence. Although chronic ankle joint instability is known to recur after surgical stabilisation, exact recurrence rates are often not reported. As duration of treatment effect may affect treatment choice, critical appraisal of injury recurrence, and therefore long-term follow-up, is important. Capsular shrinkage is a technique that initially showed promising short-term outcomes. For this reason we decided to
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perform a long-term follow-up in a retrospective setting to evaluate the duration of treatment effectiveness (e.g. function, and recurrent sprains or instability) (Chapter 9). Despite good short-term outcomes (i.e. postoperative function and satisfaction), long-term follow-up 12 to 14 years after initial surgery showed a high incidence of patients reporting recurrent sprains (56%), and persisting symptoms (e.g. pain, swelling, instability or locking) or limitations in ADL and sports (100%). This was not surprising, as previous studies have shown that capsular shrinkage does not resolve ligament laxity. Also the joint capsule is heated to the point of tissue necrosis, eventually leading to stretching of the capsular tissue. The number of recurrent sprains could not be compared to other stabilisation techniques, as for the latter recurrent sprains have not been reported. Compared to other reports in literature capsular shrinkage has shown inferior functional outcome, greater joint stiffness, and higher postoperative osteoarthritis and reoperations rates compared to anatomic reconstruction. As reoperations have been reported for all surgical stabilisation techniques, patients should be informed of the risk of chronic ankle joint instability. As capsular shrinkage provides a high risk of reoperations and persistent complaints we do not recommend it as treatment modality in patients who suffer from chronic ankle joint instability.

Conclusions

An ankle sprain should be addressed as a multidimensional problem. Chronic ankle joint instability is also complex and again requires a multidimensional approach ensuring correct diagnosis, individualised treatment and injury prevention. Conclusions concerning the management of these injuries that can be drawn based on the studies included in this thesis comprise:

- The main focus of the diagnostic process is to first exclude a fracture through physical examination and if indicated radiographic imaging (Chapter 2);
- Ligament damage is most reliably assessed through delayed physical examination 4 to 5 days after the initial ankle sprain (Chapter 2);
- In case of a lateral ankle ligament rupture, treatment with an ankle brace, combined with (supervised) exercise therapy, provides the best patient recovery (Chapter 2);
- Individual risk factors are recommended targets of treatment and prevention strategies to optimise outcome in patients who sustained a lateral ankle sprain and prevent chronic lateral ankle joint instability (Chapter 2 & 5);
- To reliably measure ankle alignment on an anteroposterior radiograph, the projection angle cannot exceed 10° of internal or external rotation of the ankle (Chapter 3);
- Treatment effectiveness can be reliably evaluated using the Dutch version of the Cumberland Ankle Instability Tool (Chapter 4);
- A higher BMI (0.56 points) is a risk factor for sustaining an ankle sprain (Chapter 5);
- A higher weight (2.5kg) and a longer time to stabilise (+0.23sec) are risk factors for chronic ankle joint instability (Chapter 5);
Radiographs made at the ER, may additionally be used to assess bone geometry, to evaluate the risk of recurrent sprains and chronic ankle joint instability (Chapter 5 & 6);

Patients in whom bone geometry is a risk factor for recurrent sprains or chronic ankle joint instability, surgical treatment of the lateral ligament laxity may be considered (Chapter 5 & 7);

A risk assessment model is mandatory to define which patients are at risk of recurrent sprains and of chronic ankle joint instability, in order to identify patients in need of early surgical stabilisation (Chapter 6);

The fibular position can be reliably assessed as a risk factor for recurrent sprains using lateral radiographs (Chapter 7);

In patients who need surgical stabilisation, anatomic reconstruction and anatomic repair are preferred over non-anatomic techniques (Chapter 8 & 9);

Capsular shrinkage is not recommended as a surgical technique to treat chronic lateral ankle joint instability (Chapter 9).

Future directions

To optimise the outcome for patients who have sustained a lateral ankle sprain, treatment focuses on functional support by means of a brace and supervised exercise therapy. Additionally, a stepwise rehabilitation plan facilitates quick and relapse free return to work and sport. To increase effectiveness of treatment and prevent persisting complaints and recurrent sprains, risk factors for sustaining an ankle sprain or chronic lateral ankle joint instability (e.g. weight, BMI and prolonged stabilisation times) should be addressed. If functional treatment provides insufficient recovery, surgical stabilisation through anatomic reconstruction or repair, are to be considered.

Now direction is provided by identification of the best evidence based treatment, treatment outcomes may be further improved by linking diagnostic findings to treatment choices. Previous studies on lateral ankle sprains have shown that classification of the severity of ligament injury is indicative for treatment effectiveness. Future research may focus on matching the diagnostic and treatment phase to improve treatment effectiveness in an early phase.

Anatomic based techniques (i.e. anatomic reconstruction and anatomic repair) have shown superior outcomes compared to non-anatomic reconstruction. An RCT comparing different anatomic stabilisation techniques may help further improve surgical treatment outcomes, identifying whether either of the techniques is superior in stabilising the ankle. Additionally, as these procedures are performed both open and arthroscopically, comparison of these approaches is necessary to be able to offer each patient the best treatment option, regardless of a surgeon’s preference. As the anatomic based techniques are not performed for the same time period as non-anatomic techniques, long-term outcomes are still unknown. A third target of future studies should be evaluating effectiveness of current anatomic reconstruction and repair techniques and compare these with non-anatomic techniques of which the results have already been outlined in this thesis.
Further improvement of both treatment outcome and prevention of lateral ankle sprains may be established by systematic risk assessment, preferably through the use of a standardised validated model. Clinical use of this risk assessment model for patients at risk of both recurrent sprains and chronic instability in an early phase (i.e. at or shortly after the presentation at the ER), will allow both adequate follow-up and on-time individualised treatment.

Brace use has shown to be effective in both the treatment and prevention of ankle sprains. The exact mechanisms that lead to this effect remain unclear and patients are often afraid brace use will affect their sports performance. To further improve effectiveness of prevention strategies and therapy compliance when prescribing an ankle brace, duration of restrictive properties on joint motion during sports activities, negative effect on sport-specific performance need to be identified.
Figure 10.1 Summary of findings and points of engagement to improve diagnostics, treatment and secondary prevention in patients who sustained a lateral ankle sprain.