Management of the posterior malleolus in trimalleolar fractures

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General introduction and outline of this thesis

CHAPTER 1

INTRODUCTION

Ankle fractures are among the most common fractures diagnosed at the Emergency Department (ED). These fractures are common in both young athletes, due to the trauma mechanism, and in older women due to osteoporosis. Every year, approximately 107 to 187 out of 100.000 people will sustain an ankle fracture[1,2]. An estimated total off around 30.000 people with ankle fractures will visit the EDs in the Netherlands annually[1].

The bony ankle joint consists of the tibia, fibula and talus. On the medial side it is stabilized by the ligamentous complex of the deltoid ligament (figure 1). Laterally several ligamentous complexes of the talofibular complex and syndesmosis stabilize the ankle joint. The syndesmosis, in between the distal tibia and fibula, consists of the Anterior Inferior Tibiofibular Ligament (AITFL), the Posterior Inferior Tibiofibular Ligament (PITFL) and the interosseous membrane.

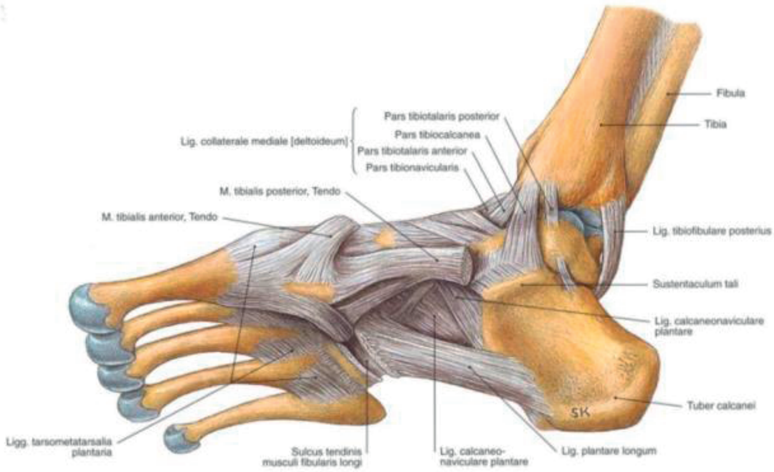

Figure 1: Medial aspect of the ankle and view on lig. tibiofibularis posterius.

The distal posterior tibiofibular ligament (PITFL) is on the posterior side attached to the posterior margin of the distal tibia. The typical rotational injury mechanism of the ankle fracture may cause the posterior inferior tibiofibular ligament to rupture or may lead to an avulsion fracture of the posterior tibial margin. Also known as the posterior malleolar fracture, Volkmann's fracture or tertius fragment (figure 2). A substantial part of all ankle fractures (7-44%) involve the posterior malleolus[3]. Since Coopers' description of the trimalleolar fracture in 1822, several publications have discussed and analyzed the challenges and pitfalls of posterior malleolar fractures[4-7]. Despite all research and publications, a worldwide consensus on the optimal treatment of the posterior fragment in trimalleolar fractures is still lacking.

Figure 2: Posterior view of the ankle.

The diagnosis of a trimalleolar fracture is usually based on findings of combined mortise, AP and lateral X-rays. Dependent of the ankle classification system used, the inter- and intraobserver variability of ankle classification systems on plain radiographs is poor to moderate[8-10]. In daily hospital setting however, standard ankle X-rays are the first means of diagnostics in case of suspicion of an ankle fracture. In the last years, preoperative CT-scanning of the intra-articular ankle fracture has become more and more common, even mandatory in some hospital protocols. Visualisation of the intra-articular fracture fragments, including the posterior malleolus fragment by CT-scan helps to better understand the fracture. It also may have implications for the treatment strategy, as advocated by several authors[10-13]. Therefore a preoperative CT-scan of the ankle joint is highly recommended in all X-ray diagnosed trimalleolar fractures[10-13].

This first CT-based classification was developed by Haraguchi et al and relied on the analysis of axial CT scans of 57 patients (figure 3)[14]. These authors distinguished three types:

- Type I: posterolateral oblique fracture as the most common variant (67%). The fracture involves a triangular fragment separated from the posterolateral part of the distal tibia.
- Type II: medial extension fracture (19%) affects the posterior part of the medial malleolus and may be formed by one or two fragments.
- Type III: small-shell fracture (14%) involves small fragments of the posterior cortex

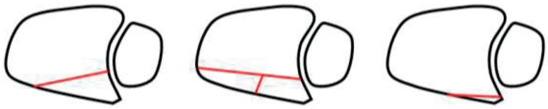

Figure 3: Haraguchi classification of posterior malleolar fractures.

Another classification system is described by Bartonicek and Rammelt[15,16]. These authors, in 2015, analyzed 141 consecutive CT scans of individuals with an ankle fracture or fracture-dislocation of types Weber B or Weber C with fracture of the posterior malleolus. The fragments were analyzed in the transverse, sagittal, and frontal planes; a 3D CT reconstruction was performed in 91 patients. The fractures of posterior malleolus were classified into four basic types having constant pathoanatomic features, with special reference to involvement of the fibular notch (Fig. 4):

- Type 1: extraincisural fragment (8%);
- Type 2: posterolateral fragment (52%). The size varies from small (only the lateral portion of the posterior tubercle) up to involvement of half of the fibular notch. In a substantial amount of the cases a depressed intercalary joint fragment is present;
- Type 3: posteromedial, two-part fragment (28%). All fragments consist of two triangular portions of different size and involve the medial malleolus;
- Type 4: large, posterolateral triangular fragment (9%). A solid posterior tibial fragment (without depressed intercalary fragment) displays a triangular geometry and about one-half of the fibular notch is affected;
- Type 5: irregular osteoporotic fracture (3%). Impossible to classify the posterior malleolar fracture due to a considerable comminution of fragments, most likely caused by osteoporosis.

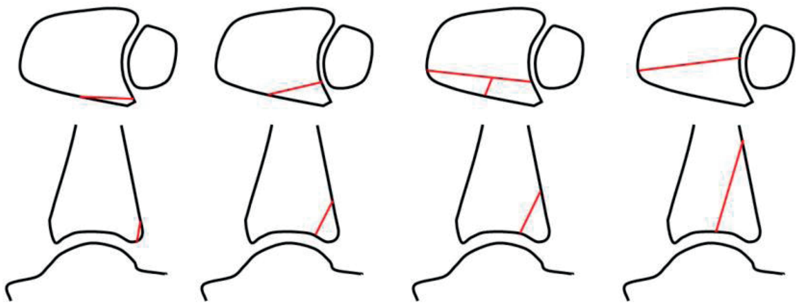

Figure 4: Bartonicek classification of posterior malleolar fractures.

The severity of injury is higher with increasing type in the classification of Bartonicek.

Traditionally, the posterior fragment is fixated if the posterior fragment exceeds 25-33% of the involved intra-articular surface[4-7]. Fixation can be performed percutaneously from anterior to posterior after closed reduction by ligamentotaxis. Until recently, this was the most common approach and way of fixation if the fragment measured more than 25-33% of the involved articular surface. Suboptimal treatment of trimalleolar fractures may result in persistent ankle instability, pain and functional impairment[4-7]. In recent literature, it is advocated to consider fixation if the weight bearing part of the tibiotalar joint is involved in the posterior malleolar fracture[16,17]. To prevent the ankle from development of posttraumatic osteoarthritis fixation is often performed at a low threshold [16,17]. No scientifically substantiated consensus exist, however, on the absolute or proportional size of the posterior malleolus fragment that warrants operative fixation[17-20].

In the past decade, open reduction and internal fixation via the posterolateral approach was advocated for posterior malleolar fractures[17,21]. Via this approach, both the fibula and the posterior tibial margin could be addressed. Theoretically, this approach has some potential benefits. Reduction is performed from posterior under direct visualisation of the fracture and if intra-articular fragments are present, these fragments can be removed by levering the posterior fragment laterally. Possible disadvantage is the relatively larger incision compared to a straight lateral or percutaneous approach only. Also care must be taken to avoid damage of the n. suralis. Complication rates of this approach have been found to be comparable to the traditional approaches[22]. It is unclear if fixation via the posterolateral approach leads to less development of post-traumatic osteoarthritis and better functional outcome.

This thesis is about the management of the posterior malleolar fragment in trimalleolar fractures and subsequently to provide evidence based guidance in treatment strategies, whenever possible. Next to management, diagnosis and optimal treatment, functional outcome and post-traumatic complications will be discussed in this thesis. Indications for fixation and (dis)advantages of different approaches, derived from different studies require to be proven in well-designed prospective studies. It is therefore that next to seven retrospective analyses, two multicenter randomized clinical trials concerning fixation of the posterior malleolar fracture fragment will be discussed in this thesis. Further planning and future perspectives will be discussed in the general discussion.

OUTLINE

This thesis aims to discuss the current and future guidelines for management of posterior malleolar fractures. Several studies were performed to specify the indications for fracture fixation of the posterior malleolar fragment. In total, nine studies were conducted and described in this thesis.

The use of modalities to diagnose a trimalleolar fracture seems to have changed over the last years. CT-scanning of the ankle in case of a posterior malleolar fragment is more and more advocated. In general, inter- and intraobserver agreement of classification systems in fracture surgery are often described as moderate to poor. The interobserver agreement of plain X-ray in malleolar fractures and the rate of comparability is described in **Chapter 2.** This study is performed in order to:

- *Describe interobserver agreement of malleolar fractures on plain X-ray*
- *Describe interobserver agreement of posterior malleolar fractures and reliability of size of posterior fragment on plain X-ray.*

In the past years multiple publications regarding treatment of the posterior malleolar fragment in trimalleolar fractures have been published. Whether and how to fixate the posterior malleolar fragment in trimalleolar fractures remains topic of debate amongst orthopaedic trauma surgeons. A close review of the available literature was indicated to narrow the research goals for this thesis. In **Chapter 3** the published literature regarding treatment and fixation methods of the posterior malleolus in trimalleolar fractures is reviewed. In this chapter the current state of the art in fixation of the posterior malleolar fracture is described. Two questions will be answered:

- *Are there any clear guidelines in current literature whether to fixate the posterior fracture fragment or not?*
- *Are there any clear guidelines regarding the optimal approach in posterior fracture fragment fixation?*

Posterior malleolus fractures are a heterogeneous group of fractures both in fracture morphology and age distribution. Potentially advices can be derived from practice variation studies. An online survey to the treatment of posterior malleolar fragments is performed in order to evaluate the current treatment in the Netherlands. The results of this survey are described in **Chapter 4** to answer the question:

- *What is the current state of practice variation in posterior fracture fragment fixation amongst (orthopaedic) trauma surgeons in the Netherlands?*

Studies that focus on trimalleolar fractures are scarce and in most available cases limited to small groups and case report. In **Chapters 5 and 6** the long-term functional and radiological outcome of a large cohort of trimalleolar fractures is described. The different aspects of a posterior malleolar fracture are analysed regarding to functional and radiological outcomes. Multiple linear regression and logistic regression analysis are used to assess risk factors for development of post-traumatic osteoarthritis and functional outcome. The following questions will be addressed:

- *Which patient and fracture characteristics lead to post-traumatic osteoarthritis?*
- *Are there significant, independent risk factors for worse functional outcome?*

Different fixation techniques and approaches are described in current literature. Most (orthopaedic) trauma surgeons do prefer a percutaneous fixation from anterior to posterior or an open reduction and internal fixation via a posterolateral approach. A comprehensive and detailed description of the posterolateral approach as used in our studies and the post-operative results and complications are described in **Chapter 7**.

In **Chapter 8**, two different fixation techniques used for fixation of the posterior malleolar fracture are compared. The differences in postoperative gap and postoperative step-off of both fixation techniques were described and evaluated. Also, both fixation methods are compared with no fixation of the posterior fragment at all. The main questions are:

- *Does open reduction and internal fixation via the posterolateral approach lead to a higher rate of anatomical reduction than reduction through ligamentotaxis and additional anterior to posterior screw fixation?*
- *Does fixation of the posterior fragment lead to a higher rate of anatomical reduction than no fixation at all?*

To our knowledge, large comparative studies on long term outcome of malleolar fractures are not available in current literature. Therefore, we performed a large retrospective study on malleolar fractures with a long-term follow-up. The results are presented in **Chapter 9.** In this chapter the different fracture patterns are described and functional outcome and radiological outcomes are compared. The following questions will be answered:

- *What are the functional and radiological outcomes in ankle fractures?*
- *Are there fracture characteristics that negatively influence functional and radiological outcome?*

Chapter 10 describes a relatively common complication**.** The ossification of the distal tibiofibular syndesmosis is called synostosis and is thought to cause a decrease in mobility of the ankle joint. The results in relation to different fracture types are described in this retrospective study.

- *Does development of distal tibiofibular synostosis lead to a worse functional outcome?*

Well-designed randomized clinical trials studying the multiple aspects on treatment and outcome of posterior malleolar fragment are scarce. A protocol for further clarification and answers to our questions is described in **Chapter 11**. Main question of this study is:

Does open reduction and internal fixation of medium-sized posterior fragments lead to better functional and radiological outcome compared to no fixation at all?

All studies and further challenges are discussed in **Chapter 12.** The English summary is written in **Chapter 13.** A short summary in Dutch and further characteristics from the author are described in **Chapter 14** and following appendices.

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