ISSN 2545-4366
www.e-mja.finki.ukim.mk

# MJA

## Macedonian Journal of Anaesthesia

A Journal on Anaesthesiology, Resuscitation, Analgesia and Critical Care

**Vol. 5 No 1, March 2021**

Journal of the Macedonian Society of Anaesthesiologists
and Macedonian Society of Critical Care Medicine

**Publisher:**
Department of Anaesthesia and Reanimation, Faculty of Medicine,
"Ss. Cyril and Methodius" University, Skopje, R.N. Macedonia

*REVIEW*

UDK: 616.718.7-001.5-089

# POSTERIOR MALLEOLUS FRACTURES – REVIEW OF THE CURRENT KNOWLEDGE AND SINGLE CENTER EXPERIENCE

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## SUMMARY

Posterior malleolar component of the ankle fractures has gained increased interest during the past decade. Several studies emphasized enormous variety of patterns of the fracture of the posterior malleolus and suggested the necessity of the recognition of its importance. Furthermore, the intimate relation of the posterior malleolar fracture with the distal tibiofibular syndesmosis has been elucidated. The traditional approach to fix the posterior malleolus based on its size as measured on the lateral x-rays, has also been questioned – radiographs have been demonstrated as inadequate for determining the size of the fracture fragment. Direct open reduction and internal fixation of the posterior malleolus via posterolateral or posteromedial approach has been recommended. Currently, in the most of the hospitals worldwide new treatment recommendations are not widely used. Also, CT scans are not routine work up for malleolar fractures. The goal of obtaining the best functional result following surgery should always be a subject of reevaluation. New achievements in a theory of surgery gain their real practical meaning in terms of patient's benefit, only when diligently applied in practice.

***Key Words:*** *ankle, classification, posterior malleolus, reduction, stability*

## Introduction

Fractures of the posterior malleolus represent about 46% of displaced Weber B and C ankle fractures (1-3). Anatomically, those are fractures of the posterior edge of the tibia, and they still represent one of the controversial aspects in relation to the treatment of the fractures of the ankle (4,5). This problem has been investigated for more than 200 years, but despite the increased interest, significant number of published studies and widespread use of the CT scans that allow for precise morphological description of the injury, there is still no consensus on the classification and treatment of these injuries (6-8).

Historically, Earle, in 1828, was the first to describe the injury to the posterior edge of the distal tibia with displaced ankle fracture (9). Chaput's radiographic examinations in 1907 and Destot in 1911 practically introduced the term posterior malleolus in the literature (10). Handerson in 1932 introduced the term trimalleolar fracture – terminology that is still generally accepted today (11).

There is a dilemma in defining the anatomical localization, i.e. the precise description of the injury. The question is still present, whether it is a fracture of the posterior malleolus or a posterior pilon fracture. In the last decade, a significant step forward has been made in understanding the nature of this injury. However, it is not always easy to answer the question and differentiate between a posterior malleolar fracture, posterior edge of the distal tibial plateau with dislocation and a posterior tibial plafond fracture or pilon fracture caused by compressive forces. It is difficult to explain the mechanism of occurrence of these fractures using the standard Lauge-Hansen classification. Posterior malleolar fractures the most commonly occur as a result of a combination of tension, compression and shearing forces. The forces that cause trimalleolar fractures with significant dislocation, as well as multifragmentary fractures caused by compressive forces where the bone fragments occupy a large part of the articular surface already represent a transition towards posterior pilon fractures. Hence, it is quite challenging to make a precise distinction, but most of the authors recommend using the transmalleolar line as a dividing line.

The subject of the classification, as well as the treatment choice are still controversial. Opinions are divided on which fracture of the posterior malleolus should be addressed surgically. The first published case of fixation of posterior malleolus via posterior approach dates back in 1920 (4, 12, 13). However, what is still somehow a practice in today's routine work, is probably from the Nelson and Jensen classification, published in 1940, which classifies the fractures in two types: so called classic type – fractures that include more than a third of the articular surface in a profile view, and minimal – fractures that occupy less than a third of the articular surface (14). Hence, surgical treatment has been recommended for the classic type. The classic type should be operatively fixed with a screw through a posteromedial approach. The rest do not need to be fixed separately. This so-called one-third rule is still in practice worldwide, and many surgeons are still guided by this classification and recommendation. However, in order to determine the right treatment of this particular entity, a detailed analysis of the type of injury is needed. Today, using modern radiological techniques, especially CT and 3D CT, the anatomical specificity of the posterior malleolus can be accurately determined (8, 15). These techniques also allow us to determine the type of fracture with great precision, and thus to find the correct treatment.

The anatomical and biomechanical aspects of this injury should be considered first. The medial malleolus is not part of the tibial pilon, hence, it does not present the articular surface through which axial compression forces are transmitted. The movement and position of the talus are limited by the posterior malleolus (15-17). The anatomical features are also important by the fact that in the lateral view, the posterior articulating edge of the distal tibial plafond extends more distally than the anterior. The medial part of the posterior malleolus is the malleolar groove in which the posterior tibial tendon is situated (18, 19). The posterior tubercle of the distal tibia forms the posterior part of the tibial notch (incisura fibularis tibiae), an important element for

the stability, as well as correct placement of the malleolar fork (tibiofibular mortise). The posterior tubercle of the distal tibia is also the origin for the posterior tibiofibular ligament, which is important for the joint stability. Here are also the attachments to the posterior joint capsule and the intermalleolar ligament. These anatomical features give the importance of the posterior malleolus in the transmission of forces as well as the stability of the ankle (20, 21).

Several cadaveric studies have been performed to demonstrate the role of the engaged articular surface in posterior malleolar fracture and its importance on stability. The results are again inconclusive, although it seems that the inclusion of the posterior tubercle and fibular notch, have impact on the stability of the ankle, and represent a relevant factor for the stability and should not be disregarded during the treatment (20, 22, 23).

## Investigations

Initial radiological examinations of the injured ankle include standard imaging in anterior-posterior, lateral and mortise views, and posterior malleolus is the most commonly seen on lateral view, but can also be indirectly detected on anterior-posterior view. However, the most accurate and precise diagnosis is made with CT on which, the medial propagation of the fragment, i.e. the intra-fragmentary depression, is clearly visualized. 3D reconstruction can give additional information and even better visualization.

## Classification

The first classification of these injuries is practically related to the clinical use of the radiographs and this historical classification in many ways does not differ from the newer radiological classifications (24).

The AO Radiological Classification, published in 1987, distinguishes three types of posterior malleolar fractures depending on the involved articular surface (25):

- Extra-articular fracture;
- Fractures with a small fragment of the articular surface;
- Fractures with large fragment of the articular surface.

This is the basis of the modern modifications of the original AO classification which are surgically acceptable and probably the most widely used.

There are classifications that are based on the analysis of data obtained from CT. The first so-called two-dimensional CT classification was published in 2006 by Haraguchi and distinguishes three types of these fractures in which data are analyzed only from transverse sections without analysis of 2D and 3D CT reconstructions (15).

In 2015, a new, so-called 3D classification by Bartonicek and Rammelt was published, which analyzed data from transverse, sagittal and frontal planes, as well as 3D reconstruction in patients with Weber B and C ankle fractures with dislocation with a posterior malleolar fracture (26). In

this classification, the fractures of the posterior malleolus are divided into four basic types with particular reference to the fibular notch:

- Type 1 – extraincisural fragment;
- Type 2 – posterolateral fragment;
- Type 3 – posteromedial, two-parts fragment;
- Type 4 – large posterolateral triangular fragment;
- Type 5 was also determined, i.e. irregular osteoporotic fracture, which was rarely observed, in 3% of the study group.

The most common type is type 2, seen in 52% of the study group.

It is noteworthy that in this study, no cases of extraarticular fragments were observed in posterior malleolus fractures. This is practically contrary to the recommended AO classification which is still widely used in clinical practice. These studies show that in all, including those of type 1 i.e. extraincisural, the part of the articular surface of the distal tibia is involved, which contributes to the severity of the injury, i.e. even in the most simple injuries according to the present classification stability of the ankle is compromised. In other words, these injuries should be carefully analyzed and treated in order to prevent late possible complications. This should be taken into account when referring to widely used AO classification.

## Indications for Surgical Treatment

The first reports for operative treatment of posterior malleolus fractures due to ankle instability, dated from the 1920 s and 1930 s (4, 12, 14, 27).

However, the real basis for surgical treatment, the principles for restoration of the articular surface of the distal tibial plafond as a basis for good postoperative results in the long term were established by the AO group, i.e. the Association for the Study of Internal Fixation (ASIF) (28-31). The basis for the indication for surgical fixation in clinical practice for a long time was, and still remains the size of the articular surface of the fractured posterior malleolus. According to this principle, posterior malleolus fracture should be fixed, if one quarter to one third of the articulating surface is involved and displacement of the fragment is greater than 2 mm, detected on the lateral view x-rays. However, recent studies using CT diagnostics show that it is virtually impossible to determine the true size of the bone fragment and articular zone involved in the fracture only by lateral radiograph view and even on 2D CT scans. Only 3D CT examination of the fracture can delineate its true nature and determine the critical size of the bone fragment and the necessity for reduction and fixation.

Using the classification of Bartonicek et al. of the posterior malleolus, based on 3D CT diagnostics of the injury, the following treatment is recommended (26):

- Type 1 (extraincisural) fractures – non-operative treatment of posterior malleolus;
- Type 2 (posterolateral) fractures – anatomical reduction and fixation of the posterior malleolar fracture, in part due to impacted intercalary fragment (Weber C), to reconstruct the

fibular notch and to provide anatomical reduction of the distal fibula to secure the stability of the tibiofibular syndesmosis;

- Type 3 (two-parts) – open reduction and internal fixation of the displaced fragments to restore tibiotalar joint congruence and stability, integrity of the fibular notch, syndesmotic stability, and medial malleolar congruence with medial fracture propagation;
- Type 4 (large triangular) – open reduction and internal fixation to restore the articular surface and ensure joint stability.

However, it should be emphasized that the choice of surgical treatment also depends on the nature of the ankle injury, which is the type of lateral malleolus fracture as well as the nature of the injury to the medial structures. This can be done through several surgical approaches and methods of open reduction and internal fixation techniques. Internal fixation can be performed with direct and indirect technique.

Overall, several surgical approaches and techniques are recommended: indirect reduction and anterior to posterior screw fixation, transfibular reduction according to Weber, direct reduction and fixation via posterolateral approach, direct reduction and fixation by posteromedial approach (32-35).

However, the choice of the surgical approach should always depend on an accurate assessment of the type of fracture. The optimal treatment for each case individually is the one that is defined by the exact morphology of the fracture based on the CT diagnosis.

Studies show that direct operative reduction and fixation of the posterior malleolus with a posterolateral and posteromedial approach is a biomechanically superior, compared to the indirect reduction and anteroposterior fixation with a screw.

## Postoperative Treatment

Postoperative treatment should be performed individually, according to the nature of the injury, type of fixation, quality of the bone and soft tissues, and the needs and expectations of the patients.

## Complications and Their Treatment

The most often the complications are related to poor reduction, regardless of the surgical approach and implant. It is necessary to make a control CT on which the position of the fixed fragments will be assessed. If the position is unsatisfactory, re-reduction should be performed to ensure a good position of the articular surface of the distal tibial plafond or correction in the presence of poor reduction of the fractured fibula which may result in poor position and impaired tibiofibular space.

Symptomatic malunion or nonunion of the posterior malleolar fragments may also occur and can be treated with a preservative osteotomy and secondary anatomical fixation if there is no or mild post-traumatic arthritis (36, 37).

In cases of severe post-traumatic arthritis, joint fusion with correction of the axis may be appropriate surgical procedure.

Post-traumatic arthritis can occur as a consequence of damage to the articular cartilage at the time of injury, or secondary, due to incongruence, when the posterior malleolus fracture has not been reduced and fixed (38-40).

## Our experience

Ankle fractures remain one of the most common injuries addressed by the skeletal surgeons worldwide. Despite significant scientific volume, treatment protocols still differ from one hospital to another. At the author's institution, total of 168 patients with ankle fractures have been operatively treated in a period of 2 years (2019 and 2020). This represents 1.28% of all operatively treated patients in the hospital. Mean age was 49.18 (range 21-76) years (46.6 years males and 49.60 years females). There was no gender predominance. In 86.2% of all cases, the ankle fracture was the consequence of a simple fall, while in the others, the injury was caused by high energy trauma. In those 13.8%, other injuries were present in 18 patients, while in 5 patients, ankle fracture was isolated injury. All the patients were operated within first 12 hours following hospital admission. According to our practice, routine preoperative CT scans were not performed, and in most of the cases, the decision on the treatment choice and type of osteosynthesis was made solely based on the x-rays. The surgery itself was performed in accordance to the AO principles. The fibular fracture was initially reduced and fixed with one-third semitubular plate, followed by the medial malleolar fracture, which was addressed with one/two malleolar screws. Posterior malleolar fractures were reduced and fixed only if the posterior fragment represented more than one-third on the profile view. Posterior malleolar fracture was reduced in indirect manner and it was fixed with one or two compression screws, placed in antero-posterior way through stab incisions (percutaneously). Once the fractures have been reduced and fixed, we checked for syndesmotic disruption demonstrated by the lateral stress test under fluoroscopic imaging; we considered the disruption to be present if there was a difference >2mm in the clear spaces (medial and tibiofibular) on the mortise views when two ankles were compared. The syndesmotic reduction was achieved with a clamp placed over the medial and lateral malleolus under fluoroscopic control and fixed with one fully threaded tricortical 3.5 mm screw.

The review of the postoperative x-rays demonstrated that of all malleolar fractures, the fracture of the posterior malleolus was present in 26% of cases (43 patients). Based on the abovementioned criterion of thirds, posterior malleolus was fixed in 28% of them (12 patients).

For the purposes of the present study, we evaluated the functional result at the minimum of 12 months post injury of the patients in whom the analysis of the preoperative x-rays demonstrated posterior malleolus fracture. We used the American Orthopedic Foot and Ankle society Score (AOFAS), which consists of three subcategories of questions related to pain, function and alignment. The best possible score presents of 100 points. The questions of alignment and range of motion are completed by the examiner.

In the group in which the posterior malleolus was fixed, the mean value of the AOFAS score was 85.33±6.7 points. In those in whom the posterior malleolus was left unfixed, the value of the score was 81.30±8.5 points. In order to compare the results, we used Student t – test, that demonstrated better result in the group in which the posterior malleolus was fixed, and the difference was presented to be statistically significant (Student t=0.43, p=0.67).

With regard to the technique used to fix the posterior malleolus, we found that in 3 out of 12 patients, the posterolateral approach with direct visualization of the fracture of the posterior malleolus and plate fixation was used, while in the others indirect reduction under fluoroscopic guidance and anterior to posterior percutaneous screw fixation was performed. The small number of those in whom direct reduction and posterior plate fixation was used, did not allow for analysis of the functional result; however, the knowledge of the significance of the posterior malleolar component of the ankle fractures will increase the rate of surgeries with direct approach.

The basic analysis of the types of malleolar fractures and the decision to operate on the posterior malleolus fractures in a single center, demonstrated low rate of fixation of the posterior malleolus fractures. New insights in the treatment of the posterior malleolar component clearly demonstrated its importance in obtaining anatomical reconstruction of the complex relationship of the anatomical structures at the level of the syndesmosis.

## Conclusion

The advancement of X-ray diagnostics, the introduction of CT into the clinical routine for the diagnosis of articular fractures, including ankle fractures, has increased interest in posterior malleolus fractures, as well as their practical significance for the final outcome of the injury.

Preoperative CT examination should become standard i.e. part of the algorithm for diagnosis of ankle fractures. Standard native radiographs are no longer sufficient for an adequate diagnosis of these injuries. Analysis of CT, 2D, and preferably in 3D, will contribute to set adequate diagnosis, and thus classification and treatment that will ultimately mean better outcomes. The 3D reconstruction will help in the differentiation of the injury, determining the main fragments for the fracture of the posterior malleolus, the involvement of the fibular notch, i.e. the fibular incisure of the distal tibia, as well as the presence of depression of the intercalary fragments. This appears to be of a greater therapeutic importance than separately observing the size of the fragment and the involvement of the articular surface. Because of this, the morphology of the injury should be carefully assessed, and surgical treatment indicated with the main goal of reconstructing the posterior tibial plafond and the fibular notch, providing adequate tibiofibular reduction, as well as ensuring the integrity of the distal posterior tibiofibular syndesmosis.

However, it is imperative to provide an individual approach i.e. choice of surgical approach and method of fixation according to the type of fracture of the posterior malleolus, but certainly as part of the treatment of ankle injury, i.e. the associated lateral and medial malleolus. The main goal is to ensure biomechanically stable fixation, which is the basis of good functional outcome.

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