Classification of Ankle Fractures

Ross Taylor

1 Introduction

Systems of fracture classification create of order out of chaos and facilitate rational inferences and treatment decisions based on related injury patterns, each of which share common anatomic or biomechanical characteristics. These characteristics form the basis for the two most used ankle fracture classification systems, the Danis–Weber and the Lauge–Hansen systems, respectively. The Danis–Weber System was subsequently incorporated into the AO/OTA (AO Foundation/Orthopaedic Trauma Association) classification, creating an exhaustive and detailed catalogue of ankle fractures. The recently recognized significance of the posterior malleolus in fracture stability has led to creation of several excellent classification systems describing fractures of the posterior malleolus, and the Mason and Malloy Classification of posterior malleolar fractures provides valuable diagnostic and treatment insights. Each of these classification systems are discussed in this chapter.

Fracture classification is useful only if the process guides clinical decision-making. Michelson et al. have demonstrated the importance of stability in determining treatment indications, with surgery largely reserved for unstable fractures. Stability of the ankle is determined by integrity of the syndesmotic and deltoid ligaments, as well as the medial, lateral, and posterior malleolus [1]. While neither the Lauge–Hansen nor Danis–Weber AO/OTA classifications are prescriptive of treatment, each stage, type, subtype, and group have implications regarding fracture stability. Each classification system may provide the greatest insights when used in combination with the other or in combination with fracture classifications of the posterior malleolus [2–7].

2 Danis–Weber Classification

The Danis–Weber Classification System of Ankle Fractures evolved from the introduction of the 3-level anatomic system introduced by Danis in 1949, which distinguished fracture types based on the level of the fibula fracture relative to the tibia-talar joint line [8]. This classification system was based on the early concept that the fibula is the key to ankle stability [9]. In 1972, Weber modified Danis' original classification to reference each of the three-alphabetically designated fracture types by the location of the anterior fibular fracture line relative to the syndesmosis (Fig. 1) [10]. Each of the three types is outlined below.

R. Taylor (✉)
Department of Orthopaedic Surgery, HCA Florida Osceola Hospital, University of Central Florida, Kissimmee, FL, USA
e-mail: Ross.Taylor@HCAHealthcare.com

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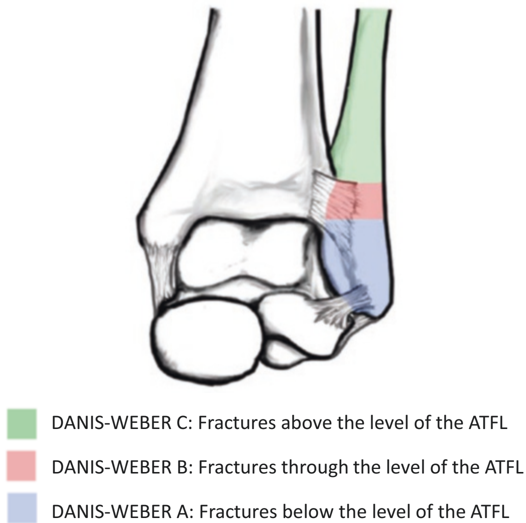

Fig. 1 Danis-Weber Classification System. Danis-Weber type-A fractures occur below the level of the tibiotalar joint (blue area). Danis-Weber type-B fractures occur at the level of the syndesmosis (red area). Danis-Weber type-C fractures occur above the level of the syndesmosis (green area)

2.1 Danis–Weber Type-A

Ankle fractures in which the fibula fracture occurs at or below the syndesmosis. These are the second most common type of ankle fracture, accounting for up to 38% of such injuries [11, 12]. These occur in isolation or in combination with fracture of the medial or posterior malleolus. When medial malleolar fractures are present, these are typically vertical and may be associated with impaction of the medial tibial plafond adjacent the fracture, as seen in Lauge–Hansen supination-adduction stage II injuries [10]. Danis–Weber A fractures usually result from forced adduction of the ankle, and as such are unlikely to involve injury to the syndesmotic or deltoid ligaments [10].

2.2 Danis–Weber Type-B

Ankle fractures in which the fibula fracture occurs through the syndesmosis. Accounting for up to 52% of ankle fractures, these injuries are usually the result of rotational forces and are therefore most closely associated with Lauge–Hansen supination-external rotation or pronation-external rotation type injuries [11, 12]. As such, this type of injury is more likely than Danis–Weber type-A fractures to be associated with fracture of the medial malleolus or deltoid ligament rupture, and the presence of a Danis–Weber type B fibula fracture should alert the clinician to the possibility of syndesmotic instability, as may be seen in up to 50% of cases [10, 13, 14].

2.3 Danis–Weber Type-C

Ankle fractures in which the fibula fracture occurs above the syndesmosis. These are the least common of the Danis–Weber fracture types yet are the most likely of the three types to represent an unstable injury, due to concomitant injuries to the syndesmosis and medial side of the ankle [11, 12]. Hinds et al. demonstrated that almost 57% of these injuries are Lauge–Hansen pronation-external rotation type injuries, and greater than 35% are supination-external rotation type [15]. Recognition of this fracture type is important, as Danis–Weber type C fractures are almost always part of an unstable fracture pattern [16].

2.4 Utility of the Danis Weber Classification

The Danis–Weber Classification System simple has good reliability as measured by low intra and inter-observer variation and is easy to apply, but alone provides limited information related to fracture outcomes [17–20]. Lacking recognition of injuries to the medial side of the ankle, this system was devised under the obsolete assumption that the distal fibula was the key to the stability of the ankle mortise. Since that time, numerous authors have demonstrated the importance of concomitant injuries to the medial side of the ankle [17, 18, 21]. Pathoanatomic factors, such as syndesmotic injury, deltoid ligament injury, or coexisting fractures of the medial or posterior malleolus, which may occur commonly in the presence of Danis–Weber type-B or C fibula fractures, are not accounted for in the Danis–Weber Classification System [7, 22]. The Danis–Weber Classification System is simple and reproducible, but provides limited useful information regarding the prognosis and treatment of ankle fractures.

3 AO/OTA Classification System

The Danis–Weber Classification was incorporated into the Association Osteosynthesis (AO Foundation)/Orthopaedic Trauma Association (OTA) Fracture Classification (AO/OTA Classification) with the inception of this system in 1996 [23]. This system standardizes fracture terminology by converting all fractures in the human body into a reproducible alpha-numeric code such that fractures of the malleolar region of the distal tibia and fibula are assigned the numeric designation of 44.

When combined with the Danis–Weber Classification System to denote the level of the fibular fracture relative to the syndesmosis, malleolar fractures are divided into three types:

Type 44A—infrasyndesmotic fibula fracture (Fig. 2)
Type 44B—transsyndesmotic fibula fracture (Fig. 3)
Type 44C—suprasyndesmotic fibula fracture (Fig. 4).

Each of these three fracture types is then divided again into three-numerically designated groups, depending on the presence or absence of coexisting fractures, ligamentous disruptions, or fracture comminution. Finally, each group is further classified into three subgroups, which is delineated by a decimal point, based on the presence of fractures or ligamentous injuries in addition to those specified at the group level [24].

The AO/OTA Fracture Classification adds qualification codes that injury morphology specific to certain fracture subgroups. These qualifications may delineate the precise location of disruption of the syndesmosis, such as whether disruption of the anterior syndesmosis has occurred at the fibular insertion (Wagstaffe's Tubercle) or at the tibial origin (Chaput's Tubercle) with certain groups of 44B-type fractures. Similar designations are present to convey the presence or absence of syndesmotic instability or the location of proximal fibular injury with certain groups of 44C-type fractures. These qualification codes trail the subgroup number in parenthesis, ultimately creating a highly specific fracture classification with 27-different injury subtypes, with multiple qualifiers possible within certain subtypes (Table 1).

Universal modifiers are available as well, which provide a single numeric code to denote variables applicable to fractures, such as displacement, dislocation, or systemic factors, such as osteoporosis. Additional lower-case letters within the modifier may be added to denote the direction of displacement or dislocation. Multiple modifiers may be used for any fracture, and modifiers are separated by commas and denoted within square brackets. While complex, the AO/OTA allows for the precise alphanumeric designation of all fractures and dislocations in the human body and even specifies metabolic conditions that may affect the fracture using universal modifiers. The reader is encouraged to reference the full range of available modifiers at: https://journals.lww.com/jorthotrauma/Fulltext/2018/01001/Introduction__Fracture_and_Dislocation.1.aspx

3.1 Utility of the AO/OTA Classification

The AO/OTA Classification greatly increases the power of Danis–Weber System, by adding additional fracture groups, subgroups, and subtypes to each of the three Danis Weber fracture types. While this level of detail is ideal for research and fracture registries, this level of specificity creates complexity, and this system cannot always be applied using radiographic criteria alone. The authors of the AO/OTA System confirm that classification depends not only on radiographic findings but may also require CT or MRI for accurate classification. Furthermore, complete classification may not be possible "until the operative pro-

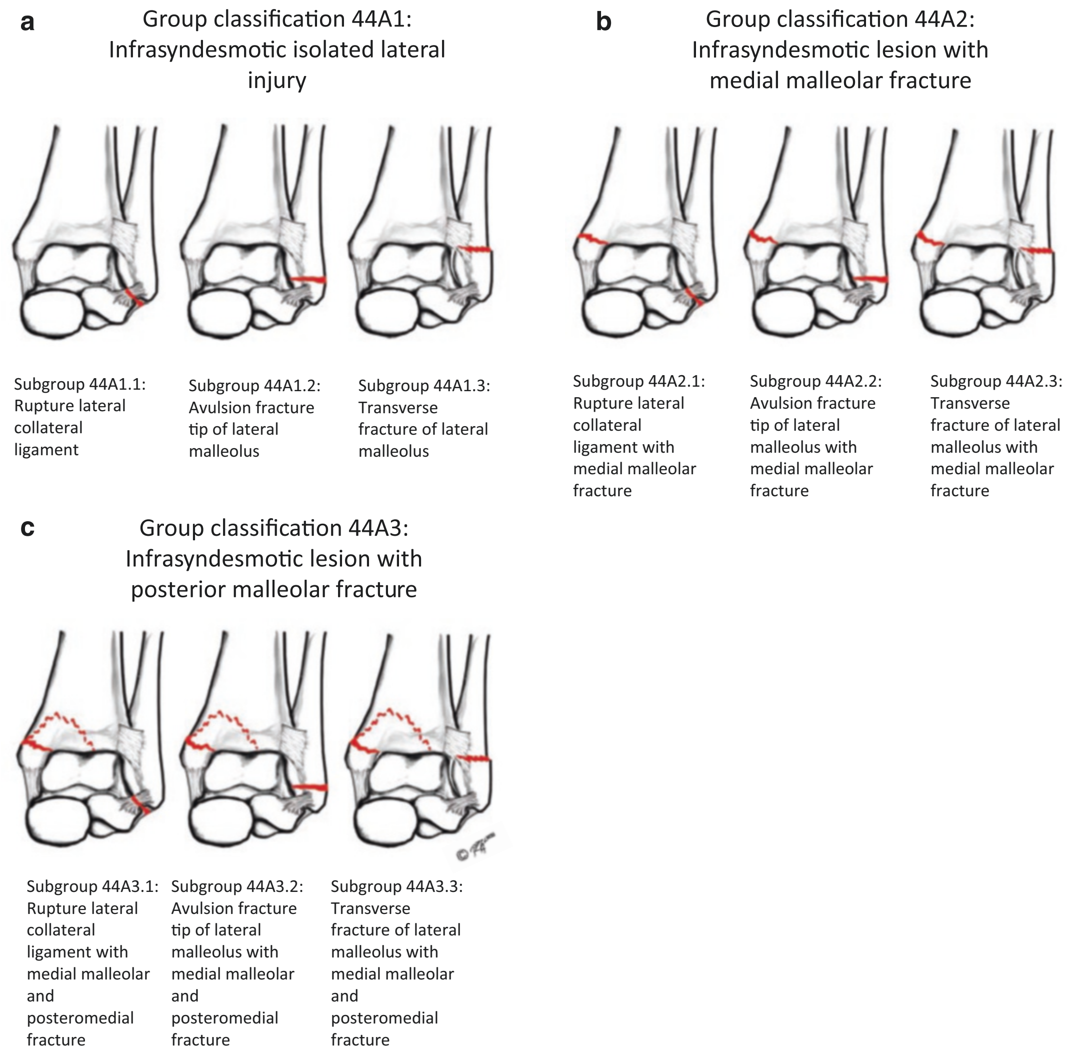

Fig. 2 OA/OTA Type 44A: Tibia/fibula, malleolar segment, infrasyndesmotic fibula injury. (**a**) Group classification 44A1: Tibia/fibula, malleolar segment, infrasyndesmotic isolated lateral injury (shaded in blue). (**b1**) Subgroup classification 44A1.1: Rupture lateral collateral ligament. (**b2**) Subgroup classification 44A1.2: Avulsion fracture of the tip of the lateral malleolus. (**b3**) Subgroup classification 44A1.3: Transverse fracture of the lateral malleolus. (**c**) Group classification 44A2: infrasyndesmotic lesion with medial malleolar fracture. (**c1**) Subgroup classification 44A2.1: Rupture lateral collateral ligament with medial malleolar fracture. (**c2**) Subgroup classification 44A2.2: Avulsion fracture of the tip of the lateral malleolus with medial malleolar fracture. (**c3**) Subgroup classification 44A2.3: Transverse fracture of the lateral malleolus with medial malleolar fracture. Group classification 44A3: infrasyndesmotic fibula injury with a posterior malleolar fracture (dashed line). Subgroup classification 44A3.1: Rupture lateral collateral ligament with a posteromedial fracture (dashed line). Subgroup classification 44A3.2: Avulsion fracture of the tip of the lateral malleolus with a posteromedial fracture (dashed line). Subgroup classification 44A2.3: Transverse fracture of the lateral malleolus with a posteromedial fracture (dashed line)

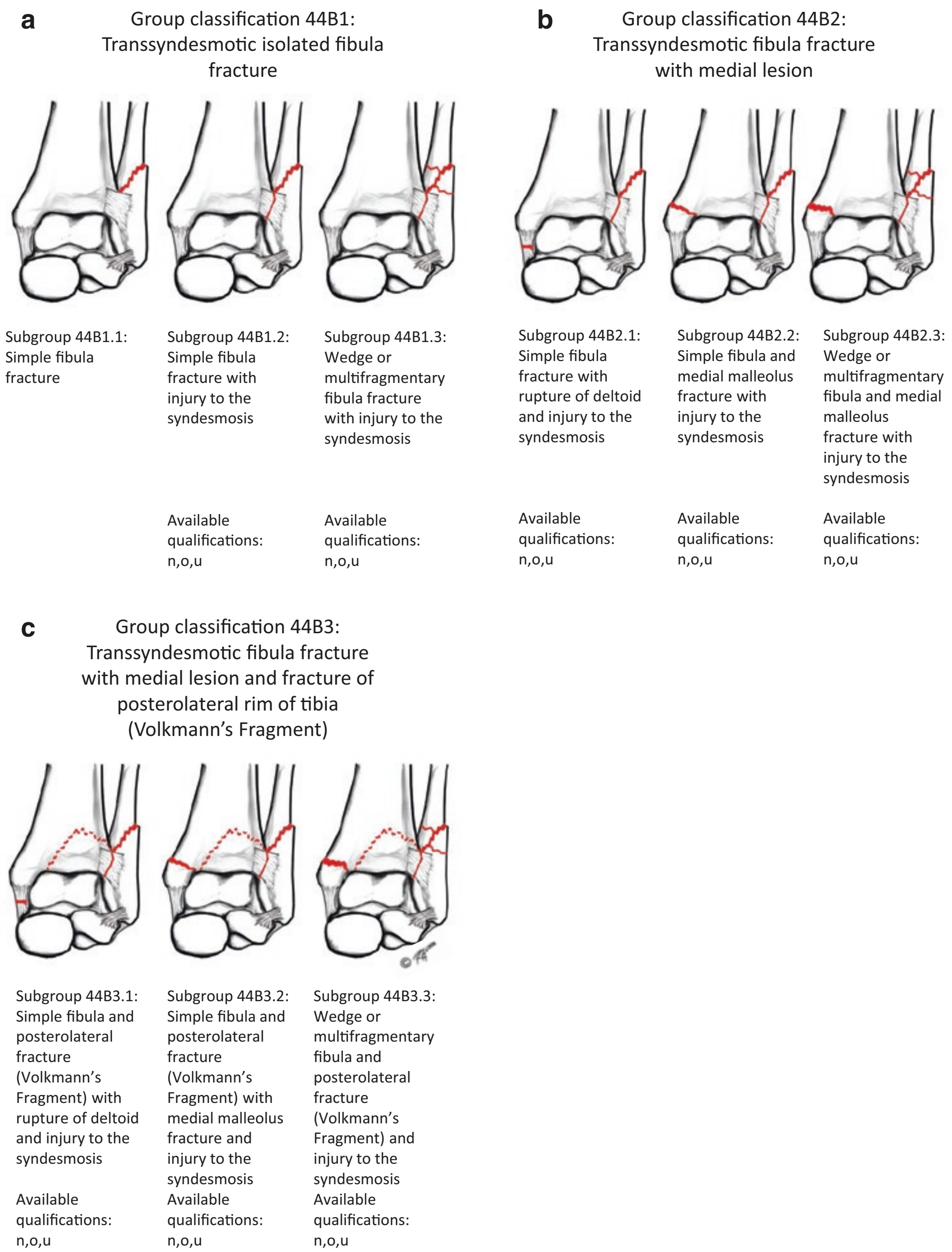

Fig. 3 OA/OTA Type 44B: Tibia/fibula, malleolar segment, transsyndesmotic fibula fracture. (**a**) Group classification 44B1: Isolated fibula fracture (shaded in pink). (**b1**) Subgroup classification 44B1.1: Simple fibula fracture. Qualifications: n,o,u. (**b2**) Subgroup classification 44B1.2: With injury to the anterior syndesmosis. Available qualifications: n,o,u. (**b3**) Subgroup classification 44B1.3: Wedge or multifragmentary fibula fracture. Available qualifications: n,o,u. (**c**) Group classification 44B2: Transsyndesmotic fibula fracture with a medial malleolus fracture. (**c1**) Subgroup classification 44B2.1: With a rupture of the deltoid ligament and anterior syndesmosis. Available qualifications: n,o,u. (**c2**) Subgroup classification 44B2.2: With a medial malleolus fracture and a rupture of the anterior syndesmosis. Available qualifications: n,o,u. Illustrated example: fracture shown as #2 would be classified as 44B2.2(n), due to fracture of Chaput's Tubercle. (**c3**) Subgroup classification 44B2.3: Wedge or multifragmentary fibula fracture with medial injury. Available qualifications: r,s,u. Group classification 44B3: Transsyndesmotic fibula fracture with a medial injury and fracture of the posterolateral rim (Volkmann's fragment) (dashed line). Subgroup classification 44B3.1: Simple, with a deltoid ligament rupture. Available qualifications: n,o,u. Subgroup classification 44B3.2: Simple medial malleolus fracture. Available qualifications: n,o,u. Subgroup classification 44B3.3: Wedge or multifragmentary fibula fracture with fracture of the medial malleolus. Available qualifications: n,o,u

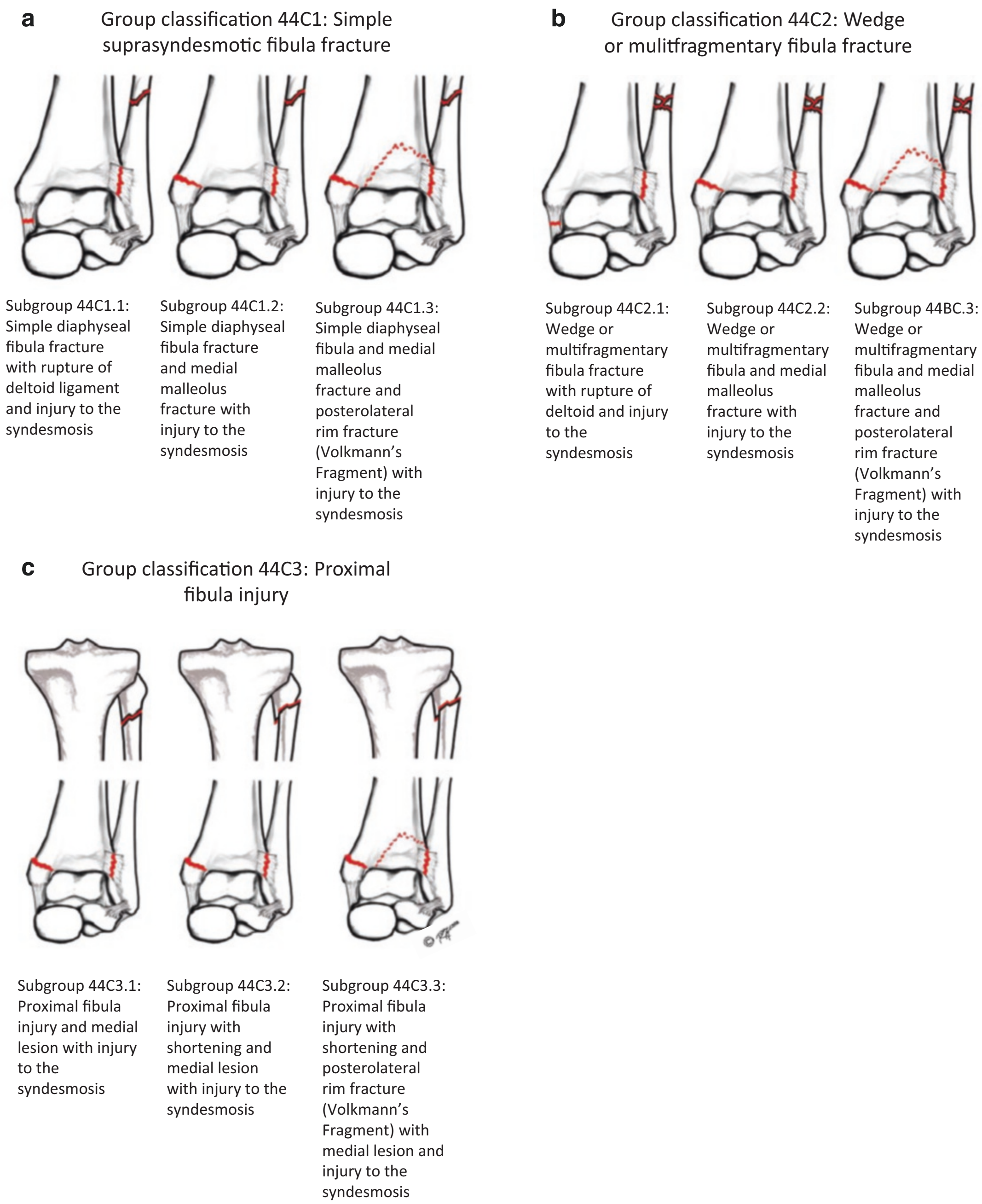

Fig. 4 OA/OTA Type 44C: Tibia/fibula, malleolar segment, suprasyndesmotic fibula fracture. (**a**) Group classification 44C1: Simple diaphyseal fibula fracture (shaded in green). (**b**1) Subgroup classification 44C1.1: With a rupture of the deltoid ligament. (**b**2) Subgroup classification 44C1.2: With a fracture of the medial malleolus. (**b**3) Subgroup classification 44C1.3: With a medial and a posterior malleolus fracture (dashed line). (**c**) Group classification 44C2: Wedge or multifragmentary diaphyseal fibula fracture. (**c**1) Subgroup classification 44C2.1: With a rupture of the deltoid ligament. (**c**2) Subgroup classification 44C2.2: With a fracture of the medial malleolus. (**c**3) Subgroup classification 44C2.3: With a fracture of the medial and posterior malleolus (dashed line). Group classification 44C3: Proximal fibula injury. Subgroup classification 44C3.1: With a medial side injury. Subgroup classification 44C3.2: With shortening and a medial side injury. Subgroup classification 44C3.3: With a medial side injury and a posterior malleolus fracture (dashed line)

Table 1 OTA Fracture qualifications

Qualification	Injury morphology
n	Tillaux–Chaput tubercle fracture
o	Wagstaffe–Le Fort avulsion fracture
p	Fibula neck fracture
q	Proximal tibio-fibular dislocation
r	Rupture of the deltoid ligament
s	Fracture of the medial malleolus
t	Syndesmosis stable
u	Syndesmosis unstable

cedure is completed and the fracture fully visualized" [23]. The high degree of specificity inherent to the AO/OTA system renders it less reproducible than other systems [12, 20, 22].

The addition of the AO/OTA subclasses to the Danis–Weber Classification System provides additional information pertaining to prognosis. The AO/OTA Fracture Classification is designed in an hierarchical manner, such that fracture severity increases within each of the Danis–Weber Groups from A to C. Similarly, within each group, injury severity increases from 1 to 3. As such, the ability of the AO/OTA Classification System to predict injury outcome has been studied. Kennedy demonstrated a significantly worse outcome with Danis–Weber type C fractures than either type A or B [25]. Sung et al. demonstrated a correlation between negative outcomes as measures using FAOS scores and injury severity as determined by AO/OTA subgroup [26].

The addition of the AO/OTA System to the Danis–Weber Classification improves the specificity of this classification and has thus contributed greatly to the understanding of how anatomic variables influence the treatment and outcomes of ankle fractures. Ultimately, the Danis–Weber/OA/OTA Classification may be more useful in combination with the Lauge–Hansen System.

4 Lauge–Hansen Classification

The Lauge–Hansen System classifies ankle fractures according to mechanism of injury using a two-part nomenclature to describe ankle fractures according to the position of the foot at the time of injury (supination or pronation) and the direction of the deforming force that creates the defined injury (external rotation, adduction or abduction) [27]. Using these principles, the Lauge–Hansen Classification System outlines four fracture types and up to four successive stages of injury for each type.

Supination injuries are characterized by initial injury to the tensioned lateral or anterolateral structures, while pronation injuries result in initial injury to the tensioned medial side. After initial injury, the direction of the deforming force determines the sequence of injury to the stabilizing bony and ligamentous structures of the ankle. This system allows the clinician to associate observed fracture patterns with potentially unseen underlying bony and ligamentous injuries on which are based the need for stress testing, advanced imaging, or surgical treatment. Not all fractures neatly fit into the Lauge–Hansen Classification System, but up to 90% or more do [15]. Each of the Lauge–Hansen type is examined below.

4.1 Supination-External Rotation (SER) (Fig. 5)

When external rotation is applied to the supinated foot, the initial structure to fail is the laterally tensioned anterior inferior tibiofibular ligament (SER stage I) (Fig. 5a). This is followed by fracture of the lateral malleolus (SER stage II) (Fig. 5b), then by rupture of the posterior tibiofibular ligament (PITFL) or fracture of the posterior malleolus (SER stage III) (Fig. 5c), followed finally by fracture of the medial malleolus or deltoid ligament injury (SER stage IV) (Fig. 5d). SER type injuries are the most common Lauge–Hansen fracture type, with series citing an incidence of between 50% and 65% of ankle fractures [11, 28].

SER injuries may be recognized by the character of the fibula fracture, which are typically spiral to variably oblique and are oriented from anteroinferior to posterosuperior. Originating within 4 cm of the tibiotalar joint, the height and length of the fibular fracture in SER III injuries may be predictive of syndesmotic instability, with longer

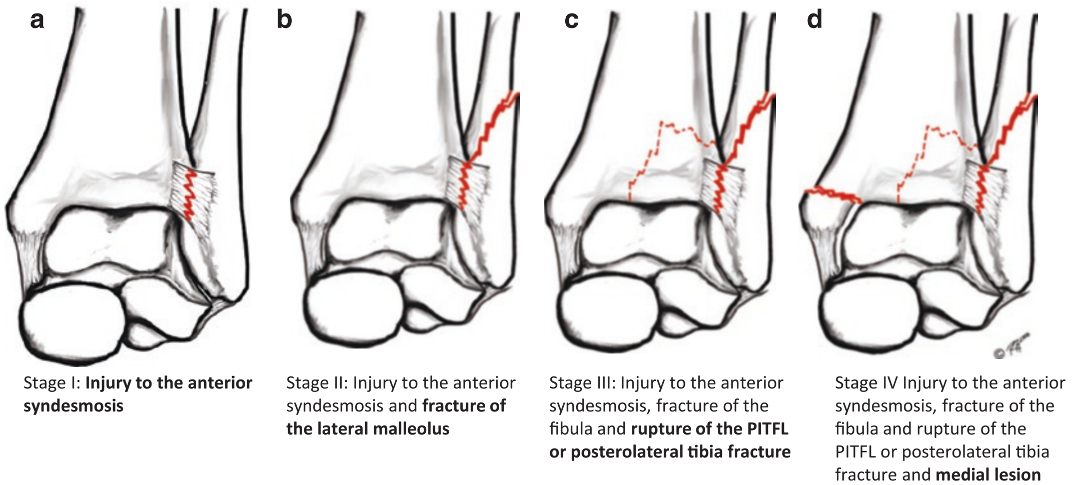

Fig. 5 Lauge-Hansen supination-external rotation type fractures. (**a**) Stage I: Anterior syndesmotic injury with rupture of the anterior tibiofibular ligament (ATFL). (**b**) Stage II: Addition of a fracture of the lateral malleolus. (**c**) Stage III: Addition of rupture of the posterior tibiofibular ligament (PTFL) or fracture of the posterior malleolus (dashed line). (**d**) Stage IV: Addition of fracture of the medial malleolus or deltoid ligament

fractures encompassing more of the insertion of the anterior syndesmotic ligaments [15, 28, 29]. The reported incident of syndesmotic instability in SER III injuries is highly variable, between 30% and 75%, and these injuries may require stress testing to determine the need for surgical treatment [28, 30, 31]. SER IV injuries are unstable, with fracture of the fibula, complete disruption of the syndesmosis, and injury to the deltoid ligament or fracture of the medial malleolus [28].

4.2 Supination-Adduction (SAD) (Fig. 6)

When adduction is applied to the supinated foot, injury begins with the tensioned lateral side and progresses medially. The first stage of SAD injuries is transverse fracture of the tensioned lateral malleolus or rupture of the lateral ankle ligaments (SAD stage I) (Fig. 6a). Continued adduction of the unrestrained talus results in a vertical fracture of the medial malleolus, and articular impaction of the medial tibial plafond may occur (SAD stage II) (Fig. 6b). SAD I injuries, as evidenced by Danis–Weber A transverse or short oblique fracture of the fibula below the level of the syndesmosis, are typically stable unless accompanied by fracture of the medial malleolus, as seen in SAD II injuries [28]. Supination adduction injuries occur in 20% or less of ankle fractures [10]. Supination adduction injuries have a worse outcome than other rotational ankle injuries and represent a transitional pattern between rotational ankle fractures and pilon fractures. This is discussed in more detail in chapter "Management of Fractures of the Tibial Plafond".

4.3 Pronation-External Rotation (PER) (Fig. 7)

External rotation of the pronated foot results in initial injury to the tensioned medial side, with either rupture of the deltoid ligament or fracture of the medial malleolus, which typically fractures in an oblique pattern (PER stage I) (Fig. 7a). Injury then progresses in an externally rotating direction to next include rupture of the anterior inferior talofibular ligament (AITFL) (PER stage II) (Fig. 7b), followed by a fracture of the fibula at or above the level of the syndesmosis (PER stage III) (Fig. 7c). In the final and most severe stage of pronation-external rotation injuries, rupture of the PITFL or fracture of the posterior malleolus at the origin of the PITFL (PER stage IV) (Fig. 7d).

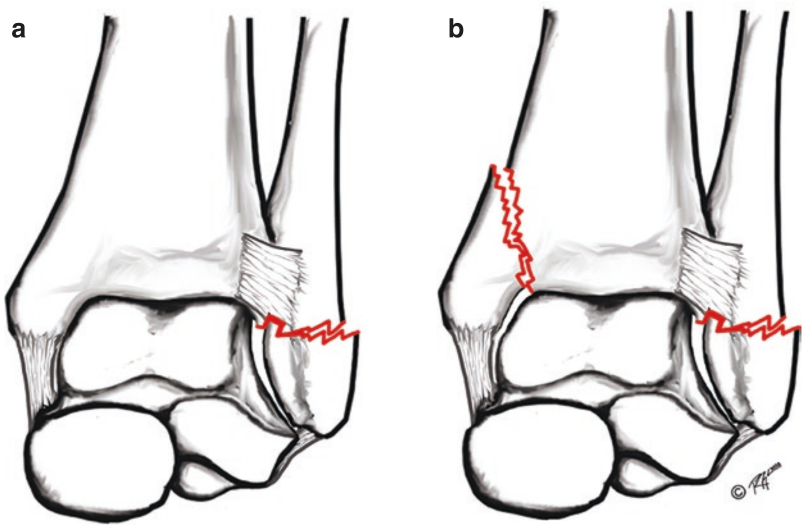

Fig. 6 Lauge-Hansen supination-adduction type fractures. (**a**) Stage I: Oblique fracture of the lateral malleolus or rupture of the lateral ankle ligaments. (**b**) Stage II: Addition of vertical fracture of the medial malleolus with or without articular impaction of the medial tibial plafond

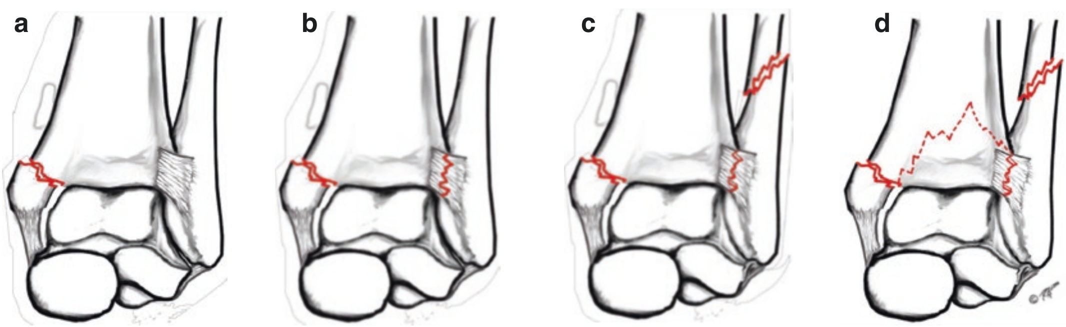

Fig. 7 Lauge-Hansen pronation-external rotation type fractures. (**a**) Stage I: Rupture of the deltoid ligament or fracture of the medial malleolus. (**b**) Stage II: Addition of anterior syndesmotic injury with rupture of the ATFL. (**c**) Stage III: Addition of oblique fracture of the fibula, with syndesmotic injury propagating to the level of the fracture. (**d**) Stage IV: Addition of rupture of the PTFL or fracture of the posterior malleolus

Most series cite an incidence of PER fractures as less than 20% of ankle fractures [10, 11].

Distinguishing PER type injuries from other Lauge–Hansen type injuries is important, as these injuries are often unstable. PER injuries may be differentiated radiographically from other Lauge–Hansen types by the directionality and height of the fibula fracture. Unlike SER type fractures, PER type fibula fractures usually progress from anterosuperior to posteroinferior, and typically originate from a more proximal location than SER types. Hinds et al. demonstrated that a fibular fracture height relative to the tibiotalar joint line of >35 mm demonstrated a 91% sensitivity in predicting a PER stage III injury, which may indicate the need for surgical management [15, 31].

4.4 Pronation-Abduction (PAB) (Fig. 8)

Abduction of the pronated foot results in initial injury of the tensioned medial side, with resultant rupture of the deltoid ligament or transverse fracture of the medial malleolus (PAB stage I) (Fig. 8a). Continued abduction of the unrestrained talus results in a laterally directed force with subsequent injury to the AITFL or avulsion of the ligamentous origin of the AITFL with fracture of Chaput's Tubercle (PAB stage II) (Fig. 8b). Finally, a short oblique or transverse fracture of the fibula may occur above the level of the syndesmosis, often with significant comminution (PAB type III) (Fig. 8c) [27]. Pronation-abduction fractures constitute a minority of Lauge–Hansen fracture types, with a reported incidence of 10% or less. Despite the low incidence of these injuries, PAB fractures are commonly open, with the sharp edge of the tibial proximal fracture fragment exposed through the relatively thin and tensioned soft tissue envelope [10, 32].

It is important to distinguish Lauge–Hanson pronation-type fractures from supination injuries. Unlike supination fractures, which are characteristically Danis–Weber type-B fractures oriented obliquely from anterior-inferior to posterior-superior, pronation fractures are more likely to originate above the syndesmosis and are oriented

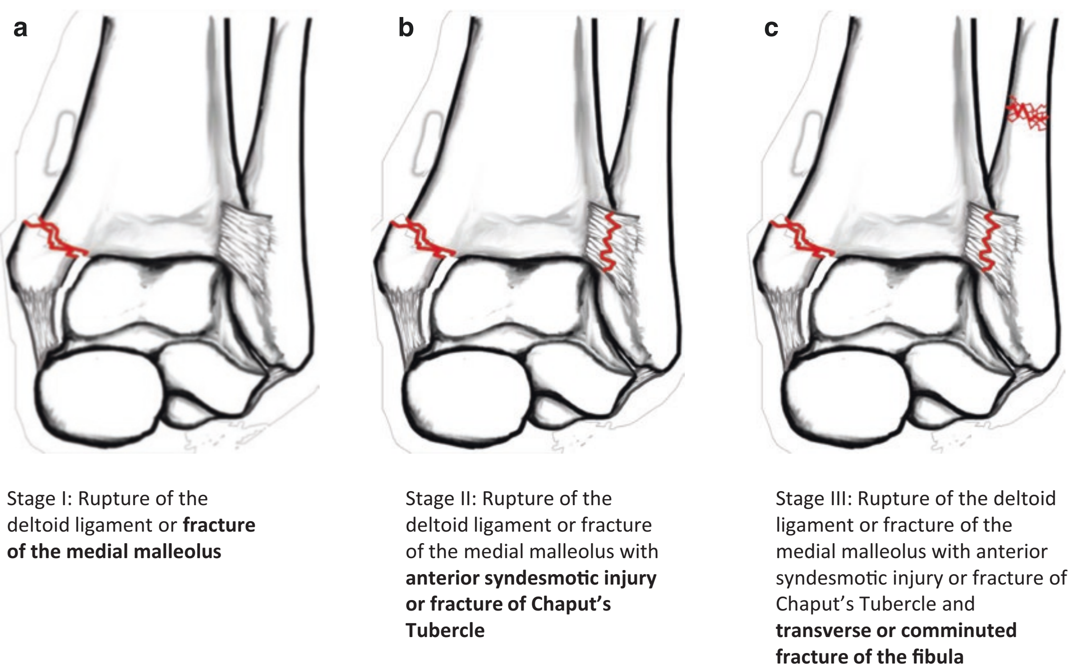

Fig. 8 Lauge-Hansen pronation-abduction type fractures. (**a**) Stage I: Rupture of the deltoid ligament or fracture of the medial malleolus. (**b**) Stage II: Anterior syndesmotic injury with rupture of the ATFL or fracture of Chaput's Tubercle. (**c**) Stage III: Transverse or comminuted fracture of the fibula, with syndesmotic injury propagating to the level of the fracture

obliquely from anterior-superior to posterior-inferior. Pronation fractures are generally higher in energy and are more likely than supination-type injuries to be unstable due to fracture of the medial malleolus or injury to the deltoid ligament [28, 33].

4.5 Utility of the Lauge–Hansen Classification

Critics of the Lauge–Hansen Classification System challenge its validity, due to an inability of authors to reproduce the originally described injury patterns using modern force reproduction techniques [6, 34, 35]. Such criticism is not surprising, given that the original work of Lauge–Hansen involved the manual application of a deforming force to cadaveric ankles that were secured to a board using commercial nails [35]. Modern techniques have allowed authors to review injury videos available on social media and correlate the observed mechanism of action to the corresponding radiographs. These studies have shown a poor correlation between radiographic fracture pattern and observed mechanism of injury [36, 37]. Michelson et al. recreated SER injuries using a system of force plates and transducers, yet these authors were unable to reliably generate injuries to the AITFL or PITFL or recreate the corresponding fractures of each ligamentous origin, that could render an advanced stage SER fracture unstable, as is implied in the original Lauge–Hansen description [6, 38].

Despite questions regarding the validity of the Lauge–Hansen Classifications as it relates to mechanism of injury, this classification system outlines reproducible patterns of ligament injury associated with individual Lauge–Hansen types that may impact treatment. Warner et al. found a greater than 85% correlation between Lauge–Hansen stage and injuries to the deltoid ligament or syndesmosis using MRI and operative findings [39]. This insight allows the surgeon to understand which fracture patterns are likely to be associated with ligamentous injuries that may render a given fracture unstable.

Greater complexity renders the Lauge–Hansen Classification System less reproducible than more simple systems such as the Danis–Weber Classification. Nielson et al. examined intra and inter-observer variability in classifying 118 ankle fractures using the Lauge–Hansen System and demonstrated agreement in only 82% of paired observations when considering Lauge–Hansen Type, and this agreement declined to less than 65% when agreement among Lauge–Hansen Stage was sought [40]. This may be because findings that determine staging, such as disruption of the deltoid ligament or AITFL, are not seen on plain radiographs.

In final analysis, the Lauge–Hansen system is a comprehensive mechanical classification system of fractures that has contributed greatly to the understanding and study of ankle fractures, particularly through the recognition of reliably recurring injury patterns that may result in instability of the ankle. Furthermore, definite inferences can be made regarding fracture stability and the need for surgical treatment based on Lauge–Hansen type and stage.

5 Mason and Malloy Classification of Fractures of the Posterior Malleolus

Up to 46% of Weber B and C ankle fractures include injuries to the posterior malleolus [41]. Traditionally, indications for surgical treatment of posterior malleolus fractures were based on the percent involvement of the articular surface, with 25% being commonly cited as the threshold for repair [16, 42–45]. More recently, Gardner et al. have demonstrated the importance of direct repair of the posterior malleolus in restoring syndesmotic stability through restoration of the origin of the PITFL, without discounting the role of the extent of articular involvement [46, 47]. As such, Haraguchi, Bartonocek, and most recently Mason and Malloy have developed posterior malleolus fracture classification systems, each of which recognize similar recurring fracture patterns [34, 46, 48–50]. Unlike fractures of the medial and lateral malleolus, fractures of the posterior malleolus are uniquely difficult to visualize on plain radiographs, and CT scan is required to understand the morphology of these fractures [49, 51, 52]. Using information gained from CT scan, the Mason and Malloy Classification System of posterior malleolus fractures may be used to provide important insights into the management of these complex fractures [38].

5.1 Mason and Malloy Type-1 Fracture

These fractures represent avulsion fractures of the posterior inferior tibiofibular ligament (PITFL) from the posterolateral distal tibia caused by external rotation of the talus within the mortise and typically involve less than 11% of the articular surface (Fig. 9a) [34]. These fractures commonly result in syndesmotic instability, the diagnosis of which may require an internal rotation stress test to detect widening of the tibiofibular clear space [38]. This fracture type is typically accompanied by an oblique distal fibula fracture and medial injury, as seen in Lauge–Hansen SER IV injury [53].

5.2 Mason and Malloy Type 2 Fractures

Type-2 fractures are characterized by a large posterolateral fragment that involves the incisura fibularis. Mason and Malloy recognized two grades of severity, based on the degree of external rotation of the talus within the ankle mortise.

Type-2A injuries are initiated by external rotation of the talus within the ankle mortis, causing bony abutment of the talus on the posterolateral tibial plafond, resulting in a large posterolateral fracture fragment. Mason and Malloy type-2A fractures are associated with a low fibular fracture, medial injury, and variably result in syndesmotic disruption. The single large posterolateral fragment produced by type-2A fractures has been found to be associated with Lauge–Hansen Type SER injuries (Fig. 9b) [19].

Type 2B injuries result from continued external rotation of the talus within the ankle mortise and propagation of the posterolateral fracture characteristic of type-2A fractures along a second fracture line 45° to the first, extending into the medial malleolus (Fig. 9c) [38]. These injuries commonly result in syndesmotic instability, due to complete disruption of the PITFL origin

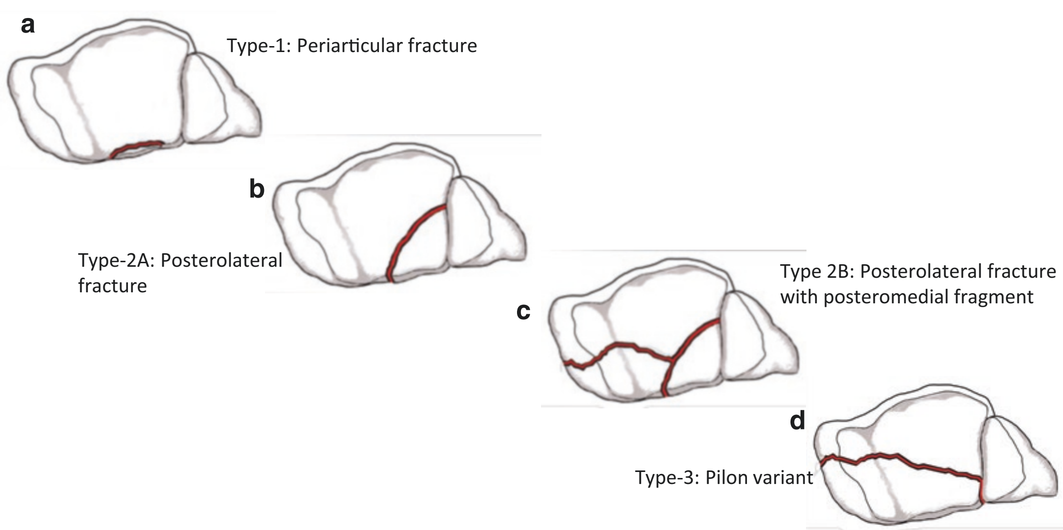

Fig. 9 Mason and Malloy Classification of posterior malleolus fractures. (**a**) Type-1: Periarticular fracture. (**b**) Type-2A: Posterolateral fracture. (**c**) Type-2B: Posterolateral fracture with posteromedial fragment. (**d**) Type-3: Pilon variant

from the posterior malleolus in combination with medial injury. Mason and Malloy Type-2B fractures are associated with advanced Lauge–Hansen Type PER injuries and are universally unstable [53, 54].

5.3 Mason and Malloy Type-3 Fracture

Characterized as a high-oblique fracture of the posterior tibial plafond, these injuries occur frequently in conjunction with a long coplanar fibula fracture (Fig. 9d). This fracture type is a pilon variant and is theorized by Mason to be caused by axial loading of the plantar-flexed talus. The syndesmosis remains stable due to the intact syndesmotic association between the large posterior tibial fragment and the long posterior fibular attachment, even though these fractures typically involve a large portion of the articular surface of the distal tibia.

5.4 Utility of the Mason and Malloy Classification

The Mason and Malloy Classification is useful in directing the surgical approach to repairing the posterior malleolus when needed to restore syndesmotic stability or articular congruity. Type-1 fractures require indirect syndesmotic repair using traditional syndesmotic fixation through a lateral approach, while restoration of the ligamentous origin of the PITFL through open reduction and internal fixation of the posterior malleolus may be preferable for type 2 or 3 fractures. Type-2A fractures are best approached posterolaterally, with the patient positioned prone. A posteromedial approach is advised for Type-2B fractures, and fracture-specific repair, usually with visualization through the coplanar distal fibula fracture is preferable for type-3 fractures [55]. Open reduction and fixation of the posterior malleolar origin of the PITFL has been shown to provide significantly improved syndesmotic stability compared to traditional syndesmotic screws [46].

Classification systems of posterior malleolar fractures provide an adjunctive tool in evaluating ankle fractures and may provide useful guidance regarding treatment. Once posterior malleolar involvement is identified on plain radiographs, as may be seen with advanced Lauge–Hansen SER or PER injuries, CT scanning may be used to identify the posterior malleolar fracture pattern, as outlined in this chapter, to guide surgical decision making.

6 Conclusion

The two most commonly used classification systems for ankle fractures are the Danis–Weber AO/OTA Classification System and the mechanistic Lauge–Hansen Classification System. The Danis–Weber Classification has the advantage of simplicity and may be combined with the Lauge–Hansen Classification System. The incorporation of the Danis–Weber classification into the AO/OTA system provides additional specificity through the addition of distinct fracture groups, subgroups, qualifications, and general modifiers, which render this classification ideal for use in research and fracture registries. The Lauge–Hansen Classification has the advantage of describing reliably reoccurring injury patterns and assigned stages of severity, which may be used to identify underlying unstable osseoligamentous injury patterns that may impact treatment. The Mason and Malloy Classification of Posterior Malleolus Fractures provides a framework for understanding fractures of the posterior malleolus and may provide insights into fracture stability and is useful in guiding surgical approach. Most importantly, each of the classification systems described in this chapter may be used to singly or in combination to guide diagnostic and treatment decisions.

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