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COMPARATIVE DESCRIPTION OF THE DANIS-WEBER, AO, LAUGE HANSEN AND DIAS-TACHDJIAN CLASSIFICATION SYSTEMS FOR ANKLE FRACTURES

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SUMMARY

Introduction: *Ankle fractures are very common in emergency departments around the world. Through time and scientific advances, several means of classification have been structured with regard to ankle fractures. The most frequent, recognized and used classification systems in ankle fractures at the moment are those of Lauge-Hansen, the AO/OTA system, Danis-Weber in adults and Dias-Tachjian in pediatrics.*

Objective: to detail the current information related to the Danis-Weber, AO, Lauge-Hansen and Dias-Tachdjian classification systems for ankle fractures.

Methodology: *a total of 37 articles were analyzed in this review, including review and original articles, as well as clinical cases, of which 24 bibliographies were used because the other articles were not relevant to this study. The sources of information were PubMed, Google Scholar and Cochrane; the terms used to search for information in Spanish, Portuguese and English were: ankle fracture classification, AO classification, Danis-Weber classification, Lauge Hansen classification and Dias-Tachdjian classification.*

Results: *In day-to-day clinical practice, the fracture itself is usually descriptively classified as a uni-, bi- or trimalleolar fracture. In the Lauge and Hanssen system, supination-adduction ranges from 10 to 20%, supination-external rotation ranges from 40% to 75%, pronation-abduction ranges from 5% to 20% and pronation-external rotation accounts for 5% to 20% of malleolar fractures.*

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The Dias-Tachdjian system shows that supination injuries are more frequent than pronation injuries, accounting for up to 82% of all ankle fractures, with supination-inversion being the most common, accounting for about 61% of all pediatric ankle fractures. With regard to the AO/OTA classification, the most common infrasyndromal fractures are A1 (isolated): 68.9%, followed by A2 (bimalleolar): 24.8% and finally A3 (trimalleolar): 6.3%. Trans-ankle fractures account for 85% of ankle fractures. Suprasyndesmal fractures are type C of the Weber classification and following the AO/OTA classification, type 44C1 would be the most common (5.3%).

Conclusions: *the importance of fracture classification systems is crucial in the choice of treatment, both conservative and surgical, as well as in the future prognosis of the affected individual. The most frequent, recognized and used classification systems in ankle fractures at the moment are those of Lauge-Hansen, the AO/OTA system, Danis-Weber in adults and Dias-Tachjian in pediatrics. In addition to the classification systems cited in this article, there are others, which may have relevance depending on the individual situation. It is important to emphasize that most of the classifications are based on a complementary study, such as radiographs or others, so knowing how to order the appropriate study and incidences helps in the future treatment of the patient with the aim of a speedy recovery.*

KEY WORDS: *classification, fractures, ankle, systems, trauma.*

INTRODUCTION

Through time and scientific advances, various means of classification have been structured with regard to ankle fractures, many of these focused on the mechanism of injury, as well as its correlation with the type of fracture. The most frequent, recognized and used classification systems in ankle fractures at the moment are those of Lauge-Hansen, the AO/OTA system, Danis-Weber in adults and Dias-Tachjian in pediatrics(1,2).

Ankle fractures are very common in emergency departments around the world, with an incidence of approximately 187/100,000 inhabitants per year. Ankle fractures are the most common fractures of the lower limb, occurring mostly in young individuals and account for almost 9% of all fractures. Especially the type B fracture according to the Danis-Weber classification, which can lead to osteoarthritis in about 14%. Regarding the type of fracture, bimalleolar fractures are associated with 1.6-5 times more probabilities of developing any complication compared to unimalleolar fractures(3-6).

The surgical treatment of ankle fractures has as its mission the anatomical restoration of the tibio-peroneo-ankle congruence, providing stability and restoring the function of the injured limb. To achieve this objective, the type of fracture should be analyzed and classified in order to treat it in the most appropriate way(7).

METHODOLOGY

A total of 37 articles were analyzed in this review, including review and original articles, as well as cases and clinical trials, of which 24 bibliographies were used because the information collected was not important enough to be included in this study. The sources of information were Cochrane, PubMed and Google Scholar; the terms used to search for information in Spanish, Portuguese and English were: ankle fracture classification, AO classification, Danis-Weber classification, Lauge Hansen classification and Dias-Tachdjian classification.

The choice of bibliography exposes elements related to current information related to the Danis-Weber, AO, Lauge Hansen and Dias-Tachdjian classification systems for ankle fractures.

DEVELOPMENT

A perfect classification for fractures should provide information regarding the stability of the fracture, the trauma mechanism producing the fracture, as well as being reproducible and providing a pathway for the choice of the best treatment(8).

Soft tissue injuries in the ankle area accompanying closed fractures are usually divided according to Tscherne and Oestern, while those accompanying open fractures are divided according to Gustilo-Anderson. Commonly, in day-to-day hospital practice, the fracture is descriptively classified as a uni-, bi- or trimalleolar fracture(9-11).

There are other classification systems commonly used because of their fundamental role in ankle fractures, some of the most frequently used are described below.

Lauge-Hansen Classification

It encompasses 4 types of injuries, based on a sequence of "pure" injuries, each of which is divided into stages of increasing severity. Based on cadaver studies. Management of ankle fractures requires an understanding of the extent of the bony and soft tissue injury. Although the Lauge-Hansen classification attempts to do this by connecting specific fracture patterns to the mechanism of injury, the experimental underpinnings of this categorization have not been meticulously reexamined using modern experimental methods(12).

The Lauge-Hansen classification takes into account:

A) the position of the foot at the time of injury.

B) the direction of the deforming force.

Supination-external rotation makes up about 40% to 75% of malleolar fractures.

Stage I: rupture of the anterior syndesmosis (anterior tibioperoneal ligament) with or without an avulsion fracture of its tibial or peroneal insertions.

Stage II: the typical spiroid fracture of the distal part of the fibula, extending from the anteroinferior zone towards the posterosuperior zone.

Stage III: rupture of the posterior syndesmosis (posterior tibioperoneal ligament) or a fracture of the posterior malleolus.

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Stage IV: transverse fracture by avulsion of the medial malleolus or a rupture of the deltoid ligament.

Supination-adduction forming about 10 to 20% of ankle fractures. It is the only type involved in medial displacement of the talus.
Stage I: transverse avulsion fracture of the fibula, distal to the joint, or a rupture of the lateral collateral ligaments.
Stage II: vertical fracture of the tibial malleolus.

Pronation-abduction forming about 5% to 20% of malleolar fractures.
Stage I: transverse fracture of the medial malleolus or a rupture of the deltoid ligament.
Stage II: rupture of the syndesmosis or a fracture by avulsion of its insertions.
Stage III: transverse or short oblique fracture of the distal end of the fibula at or above the syndesmosis; causing a lateral comminution or a butterfly wing fragment.

External pronation-rotation forming about 5% to 20% of malleolar fractures.
Stage I: transverse fracture of the medial malleolus or a rupture of the deltoid ligament.
Stage II: rupture of the anterior syndesmosis (anterior tibioperoneal ligament) with or without fracture by avulsion of its insertions.
Stage III: spiroid fracture of the distal fibula at or above the syndesmosis extending from anterosuperior to posteroinferior.
Stage IV: rupture of the posterior tibioperoneal ligament (posterior syndesmosis) or an avulsion fracture of the posterolateral portion of the tibia(1,3,13,14).

Figure 1. Ankle radiography of different types of pre- and post-surgical fractures, in which the different classification systems can be used.

Source: The Authors.

Danis-Weber Classification
It is based primarily on radiographic criteria at the level of the fibula fracture. It classifies fractures according to the level of the fibula injury with respect to the syndesmosis, dividing them into 3 types: infrasyndesmal (Weber A), transindesmal (Weber B) and suprasyndesmal (Weber C). However, this division does not assess stability because it does not take into account the medial component. Unlike the AO/OTA classification which details different groups within each type. At the moment this categorization has become the most widely used due to its simplicity and interobserver reliability. The more proximal, the greater the risk of syndesmosis rupture and instability(15,16).

It is divided into three types:
A: Fracture of the fibula below the level of the horizontal articular surface of the tibia. Equivalent to Lauge-Hansen supination-adduction. They are subdivided into A1 (isolated fractures of the lateral malleolus), A2 (associated fractures of the medial malleolus) and A3 (trimalleolar fractures).

B: Oblique or spiroid fracture of the fibula, produced by external rotation at or near the syndesmosis. Equivalent to Lauge-Hansen supination-eversion injury. They are subdivided into B1 (isolated fractures of the lateral malleolus), B2 (associated medial injury) and B3 (associated medial and posterolateral injury).

C: Fracture of the fibula above the level of the syndesmosis generating a rupture of the syndesmosis almost always associated with a medial lesion. It includes Maissonneuve and corresponds to stage III of the Lauge-Hansen pronation-eversion or pronation-abduction fractures. They are subdivided into C1 (single fibula fracture), C2 (multifragmentary fracture) and C3 (proximal fibula fractures). All of these are related to medial injuries (bony or ligamentous) and/or injuries of the posterior malleolus(3,16,17).

The Dias-Tachdjian Classification
Described in 1978 by pediatric orthopedic surgeons, it is a classification system similar to Lauge-Hansen in adults, as it attempts to describe ankle fractures with respect to the mechanism of injury using the position of the ankle and the direction of the applied force. However, the Dias-Tachdjian classification takes into account the fracture pattern with respect to the open distal tibial and fibular physis. The classification is suitable for application to young children (< 12 years) with completely open physes. This system presents four mechanisms of injury among which we have supination-inversion (SI), pronation-eversion-external rotation (PEER), supination-plantar flexion (SPF) and supination-external rotation (SER). It can be said that the level of physis closure accompanied by the mechanism of injury can show a lot of information about the fracture pattern, extension and growth plate involvement(18).

Supination-Inversion
Supination injuries are more common than pronation injuries, accounting for up to 82% of all ankle fractures. The most common of these injuries is supination-inversion (SI) with about 61% of all pediatric ankle fractures.

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Stage 1: SH type I fracture of the distal physis of the fibula, analogous to stage 1 of the Lauge-Hansen supination-adduction injury. It makes up 39% of all pediatric ankle fractures and is managed with a short leg cast for 3-4 weeks.

Stage 2: SH type I injury of the distal fibula, however, progresses to include a SH type III or IV fracture of the medial distal tibia, analogous to stage 2 supination-adduction in adults. Infrequently SH type I or II of the distal tibia with medial displacement of the entire medial displacement of the entire tibial epiphysis. It makes up 22% of all pediatric ankle fractures and these fractures are managed more aggressively. Specifically the type III/IV SH fracture of the medial distal tibia may require open reduction and internal fixation with transepiphyseal screws of the medial malleolus if there is more than 2 mm of displacement.

Pronation-Eversion, External Rotation

The most common in children is pronation-eversion, external rotation (PEER), making up 18% of all pediatric ankle fractures. PEER results in a SH type II fracture of the lateral distal tibia and a diaphyseal fracture of the distal fibula, bearing a resemblance to stage III external pronation-rotation of the Lauge-Hansen classification. This injury is usually managed with closed reduction, however, it may require a lateral incision to disengage the lateral metaphyseal fragment of the tibia, which may remain between the tibia and fibula. This type of fracture is associated with a higher rate of angular deformity and premature closure of the physis.

Supination-External Rotation (SER).

They are less common than the aforementioned injuries, accounting for less than 10% of all pediatric ankle fractures. Although the direction and force are similar to those of adult SER injuries, the pediatric fracture pattern more closely resembles that of adult Lauge-Hansen pronation-adduction (PA).

Stage 1: SH type II spiral fracture of the posterior distal tibia, resembling the posterior malleolar fracture of the adult PA stage 1 injury.
Stage 2: spiral fracture of the distal diaphysis of the fibula, in addition to the spiral fracture of the distal tibia found in stage 1 SER injury. SER injuries are managed with closed reduction with or without transmetaphyseal tibial screw fixation.

Plantar Flexion-Supination

The least common, making up less than 10% of all pediatric ankle fractures. The SPF generates a SH type II fracture of the posterior distal tibia and can be distinguished from the SER injury because it does not have the lateral-medial orientation of the spiral fracture found in SER injuries. Management is usually with closed reduction and casting for 4-6 weeks, however, external fixation of the fracture fragment may be required if it is significantly displaced by the Achilles tendon. Fixation of the distal tibia with transmetaphyseal screws may be done if there is significant displacement of the fracture fragments. A unique complication of this injury is disruption of the periosteum of the fracture fragment, which may become trapped on the anterior aspect of the fracture, necessitating an anteromedial incision and excision of the fragment prior to reduction(18-20).

Figure 2. Right Ankle Radiograph in profile, AP and oblique pre- and post-surgery.

Source: The Authors.

The AO/OTA System

Müller, Nazarian and Kock in 1987 published a general classification of fractures of alphanumeric type. Actually, it can be considered a modification of the Danis-Weber classification in which types A, B C are subdivided on the basis of the presence of medial or posterior injury:

A) Type A.
The mechanism of injury is by forced inversion of the ankle, which conditions a transverse fracture of the fibula by avulsion located at or below the level of the ankle joint or rupture of the lateral ligamentous complex. It is subdivided into:

A 1. Isolated infrasyndesmal injury.
1.Rupture of the lateral collateral ligament.
2. Avulsion of the tip of the lateral malleolus.
3. Transverse fracture of the lateral malleolus.
A2. Infrasyndesmal injury with fracture of the tibial malleolus.
1. Rupture of the lateral collateral ligament.
2. Avulsion of the tip of the lateral malleolus.
3. Transverse fracture of the lateral malleolus.

A3. Infrasin-malleolar injury with posteromedial fracture.
1. Rupture of the lateral collateral ligament.
2. Avulsion of the tip of the lateral malleolus.
3. Transverse fracture of the lateral malleolus.

B) Type B.
The mechanism of injury is by external rotation and eversion; when accompanied by posterior canthus, equinus position is added. It is subdivided into:

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B1. Transindesmal fracture of the anterior fibula.
1. Simple.
2. Simple, with rupture of the anterior syndesmosis.
3. Multifragmented.

B2. Transindesmal fracture of the fibula with medial lesion.
1. Simple, with rupture of the medial collateral ligament (deltoid) and anterior syndesmosis.
2. Simple, with fracture of the medial malleolus and rupture of the anterior syndesmosis.
3. Multifragmented.

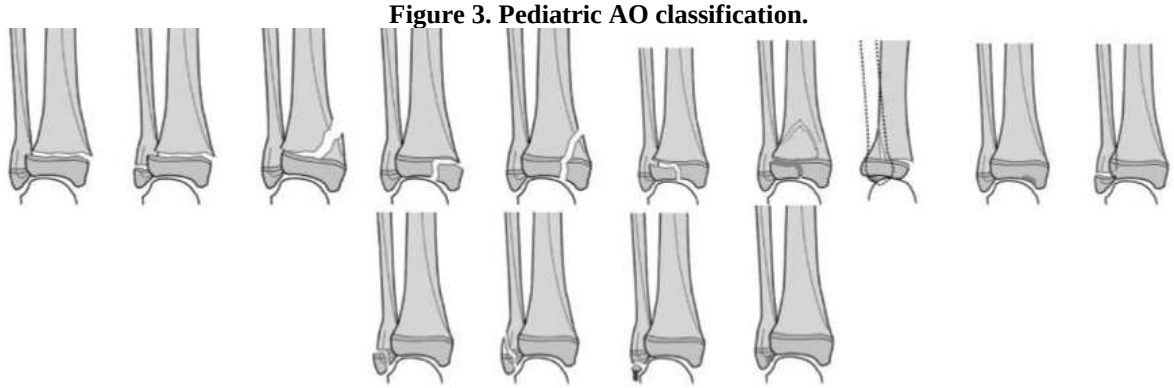
B3. Transindesmal fracture of the fibula, with medial injury and Volkmann's fracture (fracture of the posterolateral rim).
1. Simple fracture of the fibula, with rupture of the collateral and medial ligament.
2. Simple fibula, with fracture of the medial malleolus.
3. Multifragmented fibula with fracture of the medial malleolus.

C) Type C.
There is a diaphyseal fracture of the fibula between the syndesmosis and the head of the fibula. It is subdivided into:
C1. Suprasyndesmal injury, with simple fracture of the diaphysis of the fibula.
1. With rupture of the medial collateral ligament.
2. With fracture of the medial malleolus.
3. With fracture of the medial malleolus and Volkmann's lesion.
C2. Suprasyndesmal injury, with multifragmented fracture of the diaphysis of the fibula.
1. With rupture of the medial collateral ligament.
2. With fracture of the medial malleolus.
3. With malleolomedial fracture and Volkmann's lesion.

C3. Supraspinous injury, proximal fibula injury.
1. Without shortening, without Volkmann's lesion.
2. With shortening, without Volkmann's lesion.
3. With medial and Volkmann lesions(8,21).

Summarizing AO contains classifications for the whole body. The ankle is classified into (1) malleolar fractures, (2) distal tibial fractures and (3) fibular fractures. Within the malleolar fractures, the subclassifications correspond to the Danis-Weber ABC classification with the addition of a 2-digit suffix (range 1-3). The numbers correspond to an estimate of fracture severity(22).
The complexity of this classification makes it difficult to learn and apply, limiting interobserver reliability and reproducibility. There is the current pediatric AO classification, which is based on the Muller-Ao categorization for adults, but differs in that it takes into account the growth cartilage and the segmentation between metaphysis and epiphysis. Classifying in 3 main groups(8).

Figure 3. Pediatric AO classification.



Source: Ponzone A, Roncoroni A, Miscione F, Baroni EL, Dello Russo B (8).

In the AO/OTA classification, the most common infrasintemal fractures are A1 (isolated) with 68.9%, followed by A2 (bimalleolar) with 24.8% and then A3 (trimalleolar) with 6.3%. When compared with the Lauge-Hansen classification, the infrasyndesmal fractures correspond to the SAD type, with an incidence of around 10 and 20%. They can also be segmented into SAD I (transverse fibula fracture or avulsion fracture) or SAD II (associated vertical fracture of the internal malleolus). Transindesmal fractures represent about 85% of ankle fractures usually generated by a rotational mechanism, when an external rotational force is applied on the supinated foot (SER). In the AO/OTA classification, 44-B1 would be the most frequent with about 51.8%, followed by 44-B2 with 25.3% and then 44-B3 (22.9%).

Suprasyndesmal fractures represent type C of the Weber classification and, following the AO/OTA classification, 44C1 type fractures are the most common, representing about 5.3%, followed by C2 and C3 with about 3.2% and 3.4%. According to the Lauge-Hansen classification, they are observed in pronation-rotation-external type fractures and in PA fractures(16,23).

Regarding interobserver and intraobserver reliability, studies showed that the most substantial is the Dennis-Weber classification, followed by Lauge-Hansen and then the AO/OTA. It was noted that the time restriction did not present a statistically significant effect on reliability. The simultaneous use of the Weber and Lauge-Hansen system is recommended, because it presents the highest reliability and reproducibility, in addition to generating a better understanding of the type of fracture(24).

CONCLUSIONS

The importance of fracture classification systems is crucial in the choice of treatment, both conservative and surgical, as well

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as the future prognosis of the affected individual. The most frequent, recognized and used classification systems in ankle fractures at the moment are those of Lauge-Hansen, the AO/OTA system, Danis-Weber in adults and Dias-Tachjian in pediatrics. In addition to the classification systems cited in this article, there are others, which may have relevance depending on the individual situation. It is important to note that most of the classifications are based on a complementary study, such as radiographs or others, so knowing how to order the appropriate study and incidences helps in the future treatment of the patient with the aim of a speedy recovery.

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