Foot and Ankle Surgery 20 (2014) 276–280

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

The association between medial malleolar fracture geometry, injury mechanism, and syndesmotic disruption☆

Nabil A. Ebraheim MD, John T. Weston MD, Todd Ludwig MS, Muhammad Z. Moral MD, Trevor Carroll MS, Jiayong Liu MD*

Department of Orthopaedic Surgery, University of Toledo Medical Center, Toledo, OH 43614, USA

ARTICLE INFO

Article history:
Received 20 February 2014
Received in revised form 6 August 2014
Accepted 9 August 2014

Keywords:
Ankle fractures
Ankle syndesmosis
Classification
Medial malleolus fracture

ABSTRACT

Background: Precise correlations between medial malleolar fracture geometry and fracture mechanism have not been thoroughly described. This study sought to determine the prevalence of different medial malleolar fracture types and to elucidate the association between fracture geometry and fracture mechanism.

Methods: The records of 112 medial malleolar ankle fractures were reviewed. For each fracture, the direction of the fracture line in the medial malleolus (transverse, oblique, vertical, or comminuted), the Lauge-Hansen classification, and the presence or absence of syndesmotic injury was recorded. Bivariate correlation analysis was performed to determine if correlations existed.

Results: Transverse fractures were the most prevalent type of medial malleolar fracture [$n = 64$ (57%)], and they correlated with supination-external rotation injuries. These were followed by oblique fractures [29 (26)], which correlated with pronation-external rotation injuries [29 (26)], and vertical fractures [7 (6)], which correlated with supination-adduction injuries [9 (8)]. Comminuted fractures [12 (11)] and pronation-abduction injuries [22 (20)] did not correlate with any other categories. Syndesmotic injuries were correlated with transverse fractures, bimalleolar fractures, and pronation-external rotation injuries.

Conclusion: Medial malleolar fractures can be divided into four fracture types: transverse fractures, which correlated with supination-external rotation injuries; oblique fractures, which correlated with pronation-external rotation injuries; vertical fractures, which correlated with supination-adduction injuries; and comminuted fractures, which did not correlate with a particular type of injury. Syndesmotic injury was positively correlated with transverse fractures of the medial malleolus, bimalleolar fractures, and pronation-external rotation injuries. These findings suggest that medial malleolar fracture geometry can provide valuable information for the clinician when classifying and managing ankle fractures.

Published by Elsevier Ltd on behalf of European Foot and Ankle Society.

1. Introduction

Ankle fractures occur commonly, with an annual incidence of 187 per 100,000 [1]. Fractures of the malleoli make up the majority of those fractures, with an estimated annual incidence of 125 per 100,000 [2]. Fractures of the medial malleolus may occur both in isolation and in conjunction with fractures of the lateral and posterior malleoli. These injuries are commonly classified according to the Danis-Weber and Lauge-Hansen systems [3,4]. The Danis-Weber system is used to classify fractures in which the lateral malleolus is involved, and uses the level of fibular fracture in relationship to the syndesmosis as the basis of classification. This approach requires that a fibular injury be present, making it unsuitable for classifying all ankle fractures [4,5]. In contrast, fibular injury is not necessary for classifying a fracture using the Lauge-Hansen system [3,6]. The Lauge-Hansen system classifies ankle fractures based on the mechanism of the injury—derived from the position of the foot at the time of injury and the direction of the deforming force on the ankle. These classifications help surgeons identify the fracture pattern, predict soft tissue injury, determine necessary reduction maneuvers, and plan for appropriate fixation [5,7,8].

Previous studies discussing ankle fracture classifications are numerous. Much of the literature focuses on the appropriate method for classifying fractures using these systems, and several

☆ Level of Evidence: 3.

* Corresponding author at: Department of Orthopaedic Surgery, University of Toledo Medical Center, 3065 Arlington Avenue, Toledo, OH 43614, USA.
Tel.: +1 419 383 5361; fax: +1 419 383 3526.
E-mail address: jiayong.liu@utoledo.edu (J. Liu).

http://dx.doi.org/10.1016/j.fas.2014.08.002
1268-7731/Published by Elsevier Ltd on behalf of European Foot and Ankle Society.

algorithms have been proposed to better classify ankle injuries according to each system [9,10]. However, the precise relation between medial malleolar fracture geometry and fracture mechanism has not been thoroughly described. This study reviewed 112 medial malleolar fractures with goal of reporting the prevalence of different medial malleolar fracture types and identifying correlations between fracture geometry, the Lauge-Hansen classification, and the presence of syndesmotic injury.

2. Patients and methods

The fracture geometry of 112 patients who sustained ankle fractures involving the medial malleolus and had ORIF at a Level 1 Trauma Center between March 2008 and December 2011 were retrospectively reviewed. With IRB approval, participants were selected from the surgical records based upon their positive past medical history of medial malleolar fracture that was classifiable using the Lauge-Hansen system. This study's sample was taken from a larger group of 548 consecutive ankle fractures which presented to our medical center during aforementioned dates. All of the ankle fractures which did not involve the medial malleolus were all excluded, but medial malleolar fractures occurring with associated fractures (e.g. an associated talus fracture) were included in the sample.

Data on age, sex, fracture geometry, the Lauge-Hansen classification, and presence of syndesmotic injury were gathered via chart review for each patient. Patients were between the ages of 14 and 95, with a mean age of 47.9 years. Seventy of the subjects were women and 42 were men.

Pre-surgery fracture patterns were then radiographically reviewed by two separate sources (one physician, one medical student). When a disagreement arose between the two reviewers, the reviewers discussed the case together until an agreement was reached. The medial malleolar fracture geometry was categorized as either transverse, oblique, vertical, or comminuted. The number of malleoli involved in the injury (unimalleolar, bimalleolar, or trimalleolar) was noted. Additionally, the presence or absence of syndesmotic disruption was recorded. The fracture was then classified according to the Lauge-Hansen system as either supination-adduction, supination-external rotation, pronation-abduction, or pronation-external rotation (Table 1) [9,10].

To determine if there were relations between fracture geometry, the Lauge-Hansen classification, the number of malleoli involved in the ankle injury, or the presence of associated syndesmotic injury, data were statistically analyzed with PASW (Predictive Analytics Software) (version 18.0; SPSS, Chicago, IL, USA). Bivariate correlation analysis was used to identify correlations between these variables, and data with a two-tailed P-value <0.05 were considered statistically significant for this analysis.

3. Results

The prevalence of all fracture types observed in this collection of medial malleolar fractures is detailed in Table 1. Notably, transverse fractures were the most prevalent fracture type in the medial malleolar fractures studied, followed by oblique fractures, comminuted fractures, and vertical fractures. Supination-external rotation injuries were the most prevalent Lauge-Hansen type, followed by pronation-external rotation injuries, pronation-abduction injuries, and supination-adduction injuries (Table 2; Figs. 1–4).

Several statistically significant relations were identified. A transverse fracture pattern was correlated with supination-external rotation fractures (Table 3). A transverse fracture pattern was also correlated with trimalleolar fractures (Table 4) and syndesmotic injury (Table 5).

An oblique fracture pattern was correlated with pronation-external rotation fractures (Table 3) and with bimalleolar fractures (Table 4). A vertical fracture pattern was correlated with supination-adduction fractures (Table 3). Comminuted fractures were not correlated with any other fracture characteristics and occurred variably with all mechanisms.

As mentioned previously, syndesmotic injury was correlated with transverse fractures. In addition, syndesmotic injury had statistically significant correlations with two other fracture types: bimalleolar fractures and pronation-external rotation fractures. Syndesmotic injury was negatively correlated with unimalleolar fractures (Table 5).

Table 1
Medial malleolar fracture geometry encountered in this study.

	All medial malleolar fractures	Transverse fractures	Oblique fractures	Vertical fractures	Comminuted fractures
All medial malleolar fractures	112 (100)	64 (57)	29 (26)	7 (6)	12 (11)
Number of malleoli					
Unimalleolar fractures	20 (18)	9 (8)	7 (6)	1 (1)	3 (3)
Bimalleolar fractures	55 (49)	27 (24)	21 (19)	3 (3)	4 (4)
Trimalleolar fractures	37 (33)	28 (25)	1 (1)	3 (3)	5 (5)
Lauge-Hansen type					
Supination-external rotation	52 (46)	39 (35)	8 (7)	0 (0)	5 (5)
Supination-adduction	9 (8)	1 (1)	0 (0)	7 (6)	1 (1)
Pronation-external rotation	29 (26)	11 (10)	15 (13)	0 (0)	3 (3)
Pronation-abduction	22 (20)	13 (12)	6 (5)	0 (0)	3 (3)
Associated with syndesmotic injury	62 (55)	41 (37)	15 (13)	2 (2)	4 (4)

Data are reported as number (%).

Table 2
The percentage of Lauge-Hansen fracture types when subdivided by fracture geometry into transverse, oblique, vertical, and comminuted types.

	Transverse ($n=64$)	Oblique ($n=29$)	Vertical ($n=7$)	Comminuted ($n=12$)
Supination-external rotation	39 (61)	8 (28)	0 (0)	5 (42)
Supination-adduction	1 (2)	0 (0)	7 (100)	1 (8)
Pronation-external rotation	11 (17)	15 (52)	0 (0)	3 (25)
Pronation-abduction	13 (20)	6 (21)	0 (0)	3 (25)

Data are reported as number (%).