

# Fractures of the Lateral Process of the Talus: A New Classification Based on CT

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## Research article

**Keywords:** LTPF, CT scan classification, Interobserver agreement, Reliability

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# Abstract

**Background:** The common classifications of the fractures of the lateral process of the talus (LTPFs) are based on radiographs and may underestimate the complexity of LTPF, therefore, requiring a comprehensive classification based on CT (Computed tomography) scan. The aim of this study is to propose a such classification system, and to evaluate its reliability and reproducibility.

**Methods:** On the basis of the most widely recognized classifications of Hawkins as well as McCrory-Bladin, we proposed a new and comprehensive classification based on CT scan for the LTPF. We retrospectively reviewed 42 patients involving LTPF. All fractures were classified according to Hawkins, McCrory-Bladin and new proposed classification system by three surgeons. The analysis of interobserver and intraobserver agreements was done using kappa statistics.

**Results:** This new classification included two types based on presence of concomitant injuries or not, with type I consisting of three subtypes and type II of five subtypes. Interobserver and intraobserver reliability of the new classification system were almost perfect ( $\kappa=0.846$  and  $0.823$ , respectively) showing a higher interobserver and intraobserver reliability compared to the Hawkins classification ( $\kappa=0.737$  and  $0.689$ , respectively) as well as McCrory-Bladin classification ( $\kappa=0.748$  and  $0.714$ , respectively).

**Conclusion:** This new classification system for the LTPF based on CT is a comprehensive classification considering concomitant injuries. It is more reliable and reproducible and can potentially become a useful instrument for decision making of treatment options for LTPFs. Further studies on the evaluation of their clinical relevance (especially the long-term outcome) are warranted.

## Introduction

Fracture of the lateral process of the talus (LTPF) occurs infrequently, accounting for 20% of talar fractures and 0.02–0.17% of all fractures in human body [1–4]. Due to the progressive expansion in recreational sport activities, mainly snowboard, their incidence has markedly increased [5, 6]. For this reason, the LTPF has been termed a ‘snowboarder’s fracture’ [7]. Despite its increasing incidence, the LTPF is difficult to diagnose and commonly overlooked on initial plain radiographs, as it may be subtle and difficult to visualize, with a misdiagnosis rate of 15% and up to 21% by radiographs alone [8]. Therefore, CT scan can be used to verify the LTPF and should be considered when more accurately diagnosing the LTPF [9, 10].

In 1965, Hawkins initially classified LTPF into three types, simple fractures (Type I), comminuted fractures (Type II) and chip fractures (Type III) [11]. Based on Hawkins’ classification, McCrory and Bladin reorganized and proposed a similar fracture classification system, but just in a different order [12]. After then, Tinner and Sommer subdivided type III of McCrory-Bladin classification into three subtypes, but didn’t consider the concomitant injuries of LTPF [13]. All of the above classification systems are based on radiographs and possibly that they might underestimate the complexity of LTPF. It was estimated that, LTPF were associated with 19.6% of talar neck fractures and 24% of all talar body fractures [14, 15]. LTPF

may also be combined with fractures of talar head and posterior process[3]. However, by far as we know, these concomitant injuries have not been considered in any classification system regarding LTPF. Prompt and accurate diagnosis and classification of LTPF are crucial for optimized perioperative management [16]; moreover, detailed and extensive knowledge of concomitant injuries are conducive in surgical scheme making and contributed to obtaining of a better surgical outcomes. Sadly, up to date we are missing a comprehensive classification for the LTPF, which should include evaluation of LTPF and their concomitant injuries based on CT scan [17].

The objective of this study was to propose a comprehensive classification system for the LTPF based on CT and to verify its reliability and repeatability.

## Materials And Methods

### Classification

The new classification includes two types according to whether the LTPF is an isolated fracture or not.

Type I is an isolated fracture. This type is further divided into three subtypes (Fig. 1), the same as the McCrory-Bladin classification:

Ia: chip fracture without inclusion of the talofibular joint.

Ib: simple fracture with involvement of the talofibular joint.

Ic: multiple fragment fracture with joint involvement.

Type II is a lateral process fracture in combination with other fractures of the ipsilateral talus, regardless of whether the fractures involve the articular surface or not. This type is divided into five subtypes (Fig. 2):

IIa: lateral process fracture combined with talar head fracture.

IIb: lateral process fracture combined with talar neck fracture.

IIc: lateral process fracture with extension into the remainder of the talar body.

IId: lateral process fracture combined with talar posterior process fracture.

IIe: lateral process fracture combined with any two or more other fractures of the ipsilateral talus.

In order to estimate the reliability and reproducibility of the new classification we retrospectively reviewed the records of 370 cases of talus fractures, treated in our hospital from January 2010 to May 2020. The following diagnostic criteria for fractures were used:(1)older than 18 years;(2)fractures involving the lateral process of the talus;(3)preoperative and postoperative ankle plain radiographs available and(4)a

preoperative CT scan available for review. At last 42 patients (43 LTPFs, with one patient having bilateral fractures) were included in the study.

All fractures were classified by three evaluators accordingly to the Hawkins classification, the McCrory-Bladin classification and the new classification proposed. After fully understanding the classification system, three independent evaluators experienced in orthopaedics trauma surgery classified the 43 LTPFs based on the CT scan. A second round of classifying was performed 2 week later, and the case order was scrambled using a random number generator.

## Statistical analysis

Interobserver reliability was evaluated to determine the reliability of the opinions of different observers for each case. By contrast, intraobserver reliability was evaluated to determine the reliability of individual observers by comparing the first and second-round surveys for each case.

To determine the reliability of the classification systems we evaluated the interobserver agreement for each classification system using the Fleiss Kappa coefficient[18]. In order to evaluate the reproducibility of the classification system we calculated the intraobserver agreement using the Cohen Kappa coefficient [19]. Data analysis was conducted with IBM SPSS Statistics 21.0. The coefficients are interpreted using the Landis and Koch grading system, which defines the reliability or reproducibility of  $\kappa$  values  $< 0.2$  as slight, between 0.2 and 0.4 as fair, between 0.4 and 0.6 as moderate, between 0.6 and 0.8 as substantial, and values  $> 0.8$  as perfect[20].

## Results

From January 2010 to May 2020, a total of 370 patients with talus fractures were treated in our hospital, of whom 42 patients with the LTPF were included in the study. There were 37 males and 5 females with a mean age of 34.9 years (range 18–65). Fractures were present bilaterally in 1 patient, left-sided in 20, and right-sided in 21. The mechanisms of injury were a fall from large height (30 patients), a motor vehicle collision (6 patients), a fall from low height (3 patients), a sprain of ankle joint (2 patients) and a crush injury (1 patient). Among all 43 cases of LTPF, there were 9 fractures that were visible on CT but not on radiographs and the overall missed diagnosis rate was 20.9%(9/43). All the fractures were classified according Hawkins, McCrory-Bladin and new classification system.

## Interobserver agreement

The average  $\kappa$  value among the three reviewers was 0.737 when classifying LTPFs using the Hawkins classification system, 0.748 when using McCrory-Bladin classification and 0.846 when using the new classification system (Table 1). As can be seen, the new classification showed the highest interobserver reliability.

Table 1  
Interobserver agreement

	Hawkins classification	McCroly-Bladin classification	New classification
Group1	0.721	0.763	0.874
Group2	0.792	0.788	0.875
Group3	0.697	0.692	0.788
average $\kappa$ value	0.737	0.748	0.846

## Intraobserver agreement

The  $\kappa$  value was 0.689 when classifying LTPFs using the Hawkins classification system, 0.714 when using the McCroly-Bladin classification and 0.823 when using the new classification proposed (Table 2). Similarly, the new classification system has a higher intraobserver agreement than the other two classifications.

Table 2  
Intraobserver agreement

	Hawkins classification	McCroly-Bladin classification	New classification
First round	0.757	0.781	0.814
Second round	0.621	0.647	0.832
average $\kappa$ value	0.689	0.714	0.823

## Discussion

In this study, we proposed a new and comprehensive classification for LTPF based on CT scan. It was divided into two types according to whether the LTPF was an isolated fracture or not; type I was further divided into three subtypes, the same as the McCroly-Bladin classification and type II was divided into five subtypes. This proposed new classification system is simple, comprehensive and easy to remember, which we believe will provide useful information on treatment scheme making.

LTPF is an injury that is often missed because most cases are considered trivial ankle sprains due to nonvisualization of fracture on radiographs, with a resultant overall misdiagnosis rate of 15% and up to 21% by radiographs alone [21, 22]. In our study, there were 9 cases of LTPF that were visible on CT but not on radiographs and the overall missed diagnosis rate was 20.9%(9/43), which was in line with previous literature[21]. Missed or untreated LTPFs can potentially lead to permanent pain, healing in malposition,

impingement syndrome, pseudoarthrosis development and also, due to joint instability, induced a potential development of severe subtalar arthritis[23].

An ideal fracture classification system should be simple, comprehensive, reliable and reproducible[24]. Although various foot classification systems, such as the AO/OTA classification or Sneppen classification[25], do include LTPF, Hawkins as well as McCrory and Bladin are the only two classifications specifically focusing on LTPF[11, 12, 17]. Unfortunately, both classifications are based on plain radiographs and therefore underestimate the extent of these fractures due to the complexity of the ankle joint[26]. The main objective of the radiology report should be to convey the full range of fracture patterns rather than attempting to fit complex LTPF into a limited classification scheme. Additional CT scan must be employed in every patient in whom clinical doubts exist, providing additional information on concomitant injuries or associated fractures[27], which is possibly beneficial for operative program making. Therefore, in this study we proposed a new classification system based on CT to make a comprehensive classification for LTPF. Consistent with our hypothesis, the analysis results showed higher reliability and reproducibility of this new classification than previous commonly used Hawkins classification and McCrory-Bladin classification. This difference may be due to the use of a CT scan as a preoperative imaging modality, which permits a better identification of all fragments, their displacements and the areas of comminution.

If an early and accurate diagnosis of the fracture pattern is made and adequate treatment is undertaken, the prognosis of LTPF would be favorable.[28, 29]. The lateral process of the talus possesses large articulations for both the distal fibula and the posterior facet of the calcaneus. Fixation of LTPF is essential to restore the native architecture of these joint surfaces[30]. An attempt on open reduction and internal fixation can potentially improve outcome and delay development of arthritis. For the small avulsion fracture or severe comminuted fracture which cannot be treated by open reduction and internal fixation, conservative treatment or resection should be reserved [31]. The new classification provides a more comprehensive and practical method for classifying the LTPF, which may improve preoperative planning and subsequently the surgical treatment outcome.

The present study had some limitations, including its retrospective nature and the small sample size. Moreover, due to the lack of clinical data on surgical treatment, particularly the surgical outcome, the study could not confirm the correlation between this classification and clinical prognosis. A prospective study including clinical data of relatively large sample is necessitated to evaluate its clinical relevance.

## Conclusions

Based on the widespread and established classifications we present a comprehensive classification system for the LTPF based on CT. It has two types, of which type I consists of three subtypes and type II of five subtypes. The new classification system is more reliable and reproducible and can potentially become a useful instrument to adequately correlate the long-term outcomes of these fractures. Further studies on the evaluation of the classification are warranted.

# Abbreviations

LTPFs: the fractures of the lateral process of the talus;

LTPF: Fracture of the lateral process of the talus

CT: Computed tomography

# Declarations

## Authors' contributions

Yingze Zhang conceived the idea for the study; Yuchuan Wang, Yanbin Zhu and Xiangtian Deng designed the study. Zhongzheng Wang, Siyu Tian, and Zhanchao Tan collected the relevant data and classified the fractures. Xiangtian Deng and Yanbin Zhu performed the statistical analyses. Yuchuan Wang and Jiangtao Ma prepared the tables. Lei Fu did the drawings. All the authors interpreted the data and contributed to preparation of the manuscript.

## Availability of data and materials

All the data will be available upon motivated request to the corresponding author of the present paper.

## Ethics approval and consent to participate

This study was approved by the ethics committee of the 3rd Hospital of Hebei Medical University. Informed consent was obtained from all the participants.

## Consent for publication

Consent to publish was obtained from the patients detailed in this study.

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## Funding

None.

## Competing interests

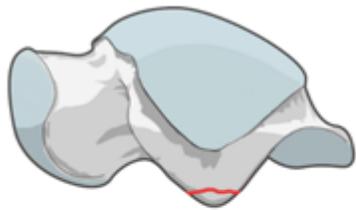
The authors declare that they have no competing interests.

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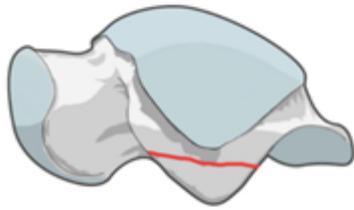
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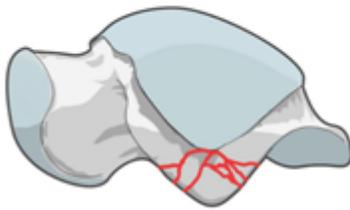
## Figures



Type Ia



Type Ib

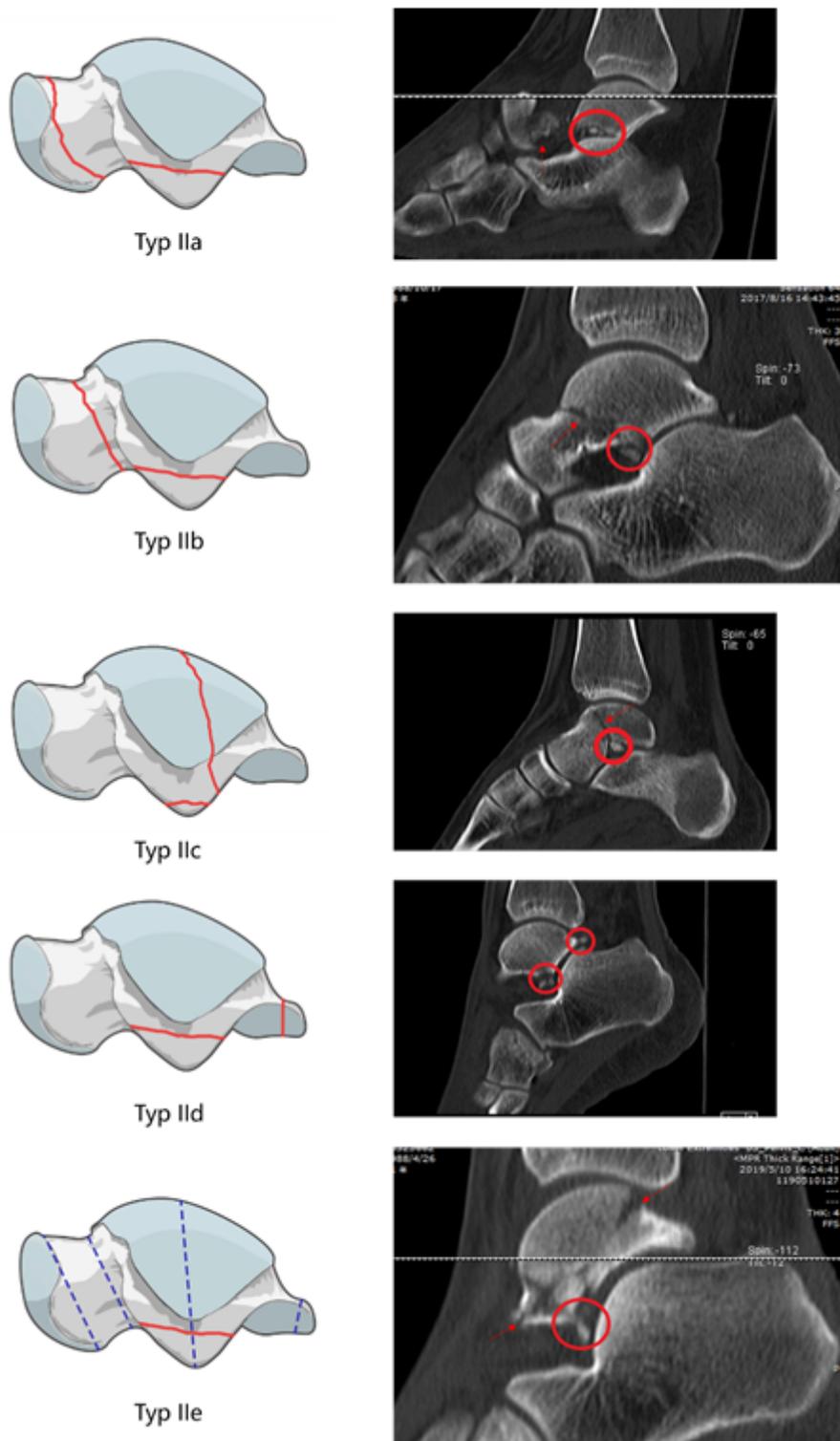


Type Ic



### Figure 1

isolated fracture: Ia: chip fracture without inclusion of the talofibular joint; Ib: simple fracture with involvement of the talofibular joint; Ic: multiple fragment fracture with joint involvement.



**Figure 2**

lateral process fracture in combination with other fractures of the ipsilateral talus: IIa: lateral process fracture combined with talar head fracture; IIb: lateral process fracture combined with talar neck fracture; IIc: lateral process fracture with extension into the remainder of the talar body; IId: lateral process fracture combined with talar posterior process fracture; IIe: lateral process fracture combined with any two or more other fractures of the ipsilateral talus.