

# Fracture Dislocations of the Tarsometatarsal Joints: Analysis of Interrater Reliability in Using the Modified Hardcastle Classification System

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*Fracture dislocations/subluxations of the tarsometatarsal joint are complex injuries that are often misdiagnosed. Prompt recognition and treatment of Lisfranc injuries decrease the likelihood of long-term sequelae. The original (1909) classification system was modified in 1982 and again in 1986. The 1986 classification system, developed by Hardcastle et al, is used most widely in clinical practice and is cited most often in the biomedical literature. For this—or any—classification system to be beneficial, however, multiple observers must be able to use it in a consistent manner, and a high level of interrater agreement should exist. This study examined interrater reliability among clinicians using the modified Hardcastle classification system for Lisfranc fracture dislocations. Thirteen Lisfranc injury radiographs were evaluated by 21 independent observers consisting of surgeons and residents (podiatric and orthopedic) as well as musculoskeletal radiologists, who classified radiographs according to the modified Hardcastle classification system. We used  $\kappa$  statistics to evaluate the degree of interrater reliability for the entire group. A mean weighted  $\kappa$  value of 0.54 was found for the group. Moderate interrater agreement was observed among clinicians interpreting the modified Hardcastle classification system for Lisfranc fracture dislocations. (The Journal of Foot & Ankle Surgery 45(5):300–303, 2006)*

Key words: classification, dislocations, fractures, metatarsal bones, observer variation, reproducibility of results, tarsal joints

Fracture dislocations of the tarsometatarsal joints are rare, comprising 0.2% of all fractures (1). This value may well be higher, because as many as 20% of these fracture dislocations are either unrecognized or misdiagnosed (2). Lisfranc injuries were first classified by Quénu and Küss in 1909 (3) on the basis of the deforming force to the foot. This classification system was subsequently modified by Hardcastle

et al in 1982 (4) and by Myerson et al in 1986 (5) to describe the type of radiographic injury pattern at Lisfranc's joint instead of describing the deforming force. Complications after fracture dislocations of the tarsometatarsal joint are multifarious and include such conditions as nonunion, malalignment, posttraumatic arthritis, and chronic foot pain (6–13). Early attempts to classify Lisfranc injuries focused on injury patterns and mechanisms—components whose identification has not been shown as helpful for directing treatment (3, 4). Despite simplified classification of these fractures, their treatment outcomes remain suboptimal (2, 4–6, 8, 9, 11, 12).

In the Hardcastle classification system as modified by Myerson et al, Lisfranc's fracture is stratified into types: “. . . type A, total incongruity of the tarsometatarsal joint in any plane or direction . . . ; type B1, partial incongruity in which the displacement affects the first ray in relative isolation (partial-medial incongruity) . . . ; type B2, partial incongruity in which the displacement affects one or more of the lateral four metatarsals in any plane (partial-lateral incongruity) . . . ; type C1, a divergent pattern, with the first metatarsal displaced medially and the lateral four in any other concomitant pattern of displacement with partial in-

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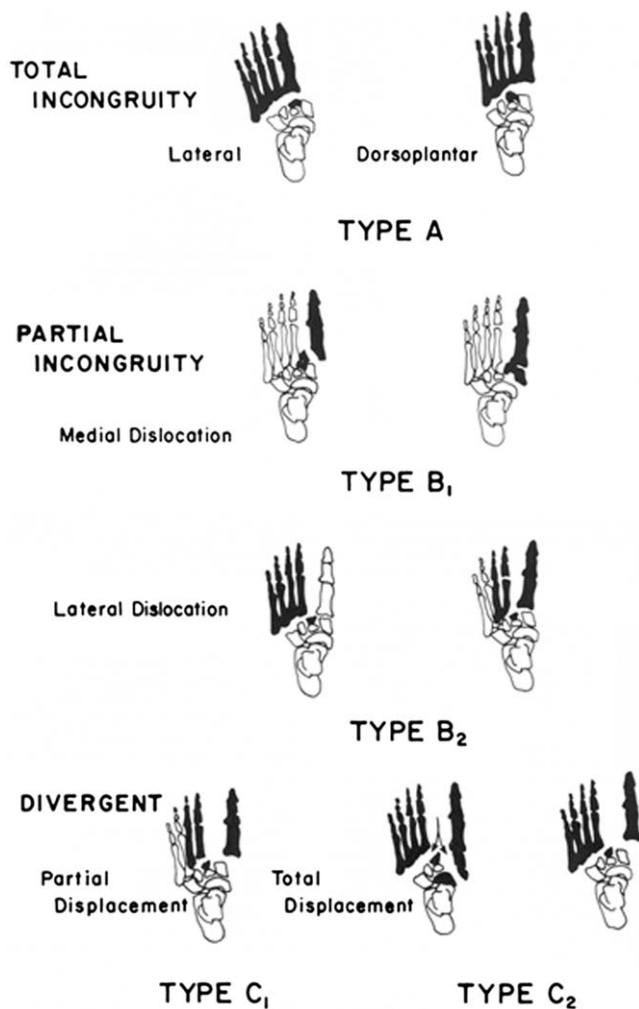
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**FIGURE 1** Diagram shows classification of Lisfranc injuries by type. (Copyright © 1986 by the American Orthopaedic Foot and Ankle Society (AOFAS). Originally published in: Myerson MS, Fisher RT, Burgess AR, Kenzova JE. Fracture dislocations of the tarsometatarsal joints: end results correlated with pathology and treatment. *Foot Ankle* 6:225-242, 1986, and reproduced here with permission from the author and publisher (5)).

congruity . . . ; and type C2, a divergent pattern with total incongruity” (Fig 1) (5).

For any classification system to be useful, results using the classification system must be interpreted consistently, regardless of which physician performs the interpretation. Our study therefore evaluated interrater reliability among physicians who used the modified Hardcastle classification system. To date, no published studies have evaluated reproducibility of this classification system.

## Methods

A prospective, methodologic interrater reliability study was conducted with 13 radiographs selected from 28 con-

secutive radiographs of unilateral tarsometatarsal fracture dislocations evaluated at 1 of 2 Kaiser Permanente (KP) Northern California Medical Centers (Oakland and Walnut Creek) between 2001 and 2005. The lead investigator (R. H. T.) selected these 13 radiographs on the basis of pattern of injury and because they most closely met any or all classification types described in the modified Hardcastle classification system. Radiographs were selected also on the basis of visual clarity. A total of 21 observers evaluated an anteroposterior-view radiograph showing a Lisfranc’s injury. All 13 radiographs showed gross disruption at the Lisfranc complex. This disruption was indicated by a fracture dislocation or subluxation between 1 or more of the metatarsocuneiform or metatarsocuboid joints. The group of physicians interpreting the radiographs included 6 attending podiatric surgeons and 7 attending orthopedic surgeons from the Department of Orthopedics and Podiatric Surgery at the KP Oakland, Richmond, and Walnut Creek Medical Centers; 5 podiatric surgery residents from the San Francisco Bay Area Foot & Ankle Residency Program; 1 senior orthopedic surgery resident from the KP Oakland Medical Center; and 2 fellowship-trained musculoskeletal radiologists from the KP Oakland Medical Center. These groups of specialists were chosen because they are the types of practitioners most likely to encounter these injuries. All attending surgeons, radiologists, and residents were individually shown only the 13 injury-related radiographs previously selected by the lead investigator. All information identifying patients was removed from the radiographs to blind the reviewers and thus eliminate bias. Participants received a handout (Fig 1) depicting the modified Hardcastle classification system and were asked to classify each radiograph according to the classification system.

The results were arranged in tabular format. To measure agreement among the evaluators, we used  $\kappa$  statistics, which evaluate the degree of agreement among different observers by calculating the observed agreement, which is then corrected for the agreement that may be expected by chance. A common interpretation of  $\kappa$  is that  $<0.00$  signifies poor agreement; 0.00 to 0.20, slight agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement; 0.61 to 0.80, substantial agreement; and 0.81 to 1.00, almost perfect agreement (14). Interrater reliability is contingent on the ability of multiple observers to evaluate injuries consistently.

## Results

Tabulated results are shown in Table 1. The mean weighted  $\kappa$  value calculated for the group was 0.54 with a standard error of 0.036 and a 95% confidence interval of 0.47 to 0.61.

**TABLE 1 Total number (%) of radiographs classed by observers\* who used the modified Hardcastle classification system to evaluate radiographs of 16 Lisfranc fracture/dislocation injuries of the foot and ankle**

Observer	Modified Hardcastle Classification Types				
	A	B1	B2	C1	C2
1	4 (30.8)	3 (23.1)	4 (30.8)	1 (7.7)	1 (7.7)
2	2 (15.4)	2 (15.4)	7 (53.8)	0 (0.0)	2 (15.4)
3	1 (7.7)	2 (15.4)	7 (53.8)	1 (7.7)	2 (15.4)
4	3 (23.1)	1 (7.7)	9 (69.2)	0 (0.0)	0 (0.0)
5	3 (23.1)	1 (7.7)	9 (69.2)	0 (0.0)	0 (0.0)
6	4 (30.8)	1 (7.7)	8 (61.5)	0 (0.0)	0 (0.0)
7	2 (15.4)	4 (30.8)	7 (53.8)	0 (0.0)	0 (0.0)
8	3 (23.1)	2 (15.4)	7 (53.8)	0 (0.0)	1 (7.7)
9	9 (69.2)	1 (7.7)	2 (15.4)	0 (0.0)	1 (7.7)
10	4 (30.8)	1 (7.7)	8 (61.5)	0 (0.0)	0 (0.0)
11	6 (46.2)	1 (7.7)	6 (46.2)	0 (0.0)	0 (0.0)
12	4 (30.8)	1 (7.7)	8 (61.5)	0 (0.0)	0 (0.0)
13	4 (30.8)	1 (7.7)	7 (53.8)	0 (0.0)	1 (7.7)
14	4 (30.8)	2 (15.4)	7 (53.8)	0 (0.0)	0 (0.0)
15	4 (30.8)	1 (7.7)	8 (61.5)	0 (0.0)	0 (0.0)
16	5 (38.5)	1 (7.7)	7 (53.8)	0 (0.0)	0 (0.0)
17	4 (30.8)	2 (15.4)	7 (53.8)	0 (0.0)	0 (0.0)
18	6 (46.2)	1 (7.7)	6 (46.2)	0 (0.0)	0 (0.0)
19	1 (7.7)	1 (7.7)	7 (53.8)	1 (7.7)	4 (23.1)
20	4 (30.8)	2 (15.4)	7 (53.8)	0 (0.0)	0 (0.0)
21	3 (23.1)	2 (15.4)	6 (46.2)	1 (7.7)	1 (7.7)

\*Including orthopedic surgeons, staff podiatric surgeons, podiatric residents, orthopedic residents, and radiologists.

## Discussion

The modified Hardcastle classification system is often used by surgeons (and is frequently cited) in the context of communicating fracture patterns and treating fractures of the tarsometatarsal joint. In general, classification systems help clinicians and surgeons to distinguish a problem and to determine the best treatment for a selected condition. Classification systems are also vital for communicating clinical data among clinicians in a way that facilitates consistent comparison of similar conditions. A classification system should be both valid and reliable.

A classification system is useful if an appropriate amount of interrater reliability exists among physicians who use the system. A widely accepted premise is that the modified Hardcastle classification system for Lisfranc fracture dislocations should not be used to direct treatment and does not attempt to stratify outcomes on the basis of fracture patterns. To date, no published studies have evaluated reproducibility of this classification system. Such evaluation is important for understanding that published data regarding the classification of Lisfranc injuries using the modified Hardcastle classification system may vary according to physicians' interpretation of fracture patterns. Our study is the first to examine interrater reliability among clinicians who use the modified Hardcastle classification system.

The current standard of practice for managing Lisfranc joint injuries is to establish stable anatomic reduction of the

fracture/dislocation regardless of its type within the classification system. This practice has led to the best long-term outcomes for patients with Lisfranc joint injuries (2, 5, 7, 10, 11, 15). Myerson et al (5) showed that injury patterns cannot be used for reliably predicting the clinical results of treatment. Arntz et al (9) found that as many as 90% of patients with Lisfranc injuries had intraarticular or periarticular fracture and that posttraumatic arthritis developed in 53% of these patients as a result of the fracture. The authors concluded that posttraumatic arthritis was related either to damage of the articular surface or to inadequate reduction (9). Compared with patients whose injuries were both ligamentous and osseous, patients with purely ligamentous injuries had poorer treatment outcomes despite receiving anatomic reduction and internal fixation (15). Komenda et al (16) showed that in patients who underwent tarsometatarsal arthrodesis for chronic midfoot pain secondary to foot trauma, initial evaluation may not have recognized the severity of the sentinel injury, which may have included tarsometatarsal ligamentous injury. Clinicians cannot easily or reliably determine whether a purely ligamentous injury was initially unrecognized, resulted after treatment was delayed, or was inappropriately assessed as to severity.

The initial aim of this study was to evaluate interrater reliability for 1 group of physicians and to include physicians who regularly treat disorders of the foot and ankle. The group included podiatric surgeons, orthopedic surgeons, fellowship-trained musculoskeletal radiologists, po-

diatric residents, and orthopedic residents. The mean weighted  $\kappa$  value of 0.54 for the group as a whole represents a moderate degree of reliability.

### Limitations

Radiographs were selected by the lead investigator (R. H. T.) before they were shown to physician-observers. Radiographs were selected on the basis of injury pattern most closely matching the classification types depicted in the modified Hardcastle classification system. All 13 selected radiographs showed gross disruption at the Lisfranc complex. The disruption was indicated by a fracture dislocation or subluxation between 1 or more of the metatarsocuneiform or metatarsocuboid joints.

### Conclusion

Classification systems enable physicians to communicate findings in organized, widely understood terms. Many classification systems that classify skeletal injuries on the basis of fracture pattern alone and do not direct treatment protocols. The modified Hardcastle classification system is one such example: It should not be used to direct treatment and does not attempt to stratify outcomes on the basis of fracture pattern. However, for physicians to communicate effectively, the classification system used by them to describe fractures should show a high degree of interrater reliability. This study showed that the modified Hardcastle classification system for Lisfranc fracture/dislocations has moderate interrater reliability among observers.

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