Acta Orthop. Belg., 2010, **76**, 521-525

ORIGINAL STUDY

Ankle fracture classification : an evaluation of three classification systems : Lauge-Hansen, A.O. and Broos-Bisschop

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The interobserver variability and the ability of the Lauge-Hansen, A.O. and Broos-Bisschop classification systems to encompass all the ankle fracture patterns were investigated in a study of the radiographs of 293 patients with a total of 294 malleolar fractures. Three different orthopaedic surgeons independently evaluated the sets of ankle radiographs. The examiners classified the ankle fractures using the Lauge-Hansen, A.O. and Broos-Bisschop systems. The overall percentage of unclassified fracture patterns was 0.7% with the Broos-Bisschop system, 10% with the Lauge-Hansen system and 8.7% with the A.O. system. The concordance rate using Kappa coefficient ranged from 0.327 to 0.408 for the Broos-Bisschop system, from 0.174 to 0.476 for the Lauge-Hansen system and from 0.397 to 0.483 for the A.O. system. These results show that these three classification systems have in common a considerable interobserver variability deficiency which restricts their validity in selection of treatment options, prognosis and comparison between different materials.

Keywords : ankle fracture ; classification system evaluation ; reproducibility.

INTRODUCTION

The Lauge-Hansen classification system for ankle fractures (*8*) was for many years the most commonly used system. It is based on the injury mechanism. The A.O. (ASIF) group developing the works of Danis and Weber presented its own classification system (A.O.) which is mainly anatomic (*11*).

Lindsjö found great variations in the frequencies of different types of fractures comparing different materials according to the Lauge-Hansen classification system and suggested low reproducibility of the method (*9*). In literature, the percentage of unclassified fractures ranges from 1% to 5% (*9,14*).

Comparing different materials according to the A.O. system, one can find great variations in the frequencies with which different types of fractures appear (*5,7,10*). Although numerous authors have recognized the inability of this system to account for the fractures where the lateral malleolus has been spared, one can hardly find in literature the percentage of these unclassified cases. Broos and Bisschop found in their series more than 10% medial unimalleolar fractures (*2*). These authors recognized the weaknesses of the previous classification methods

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No benefits or funds were received in support of this study

and proposed their own, which is purely descriptive (*2*).

The aim of this study was to assess the interobserver variation and the ability of the Lauge-Hansen, A.O. and Broos-Bisschop classification systems to encompass all the possible fracture patterns.

MATERIAL AND METHODS

From 1998 to 2007, 293 skeletally mature patients with a total of 294 malleolar fractures were treated surgically in our hospital. In order to eliminate the possibility of misclassification and to evaluate the orthopaedic surgeons' accuracy, we performed a pilot study : 10% of the radiographs were presented to seven candidate raters who were asked to classify them using the three classification systems herein studied. A few days later they repeated their attempt with the same sample of cases. The interobserver evaluation showed highly intraobserver concordance (k-coefficient > 0.80, p-value < 0.001) in three of them.

Using the pre-operative radiographs, they independently classified all the fractures according to Lauge-Hansen, A.O. and Broos-Bisschop methods. Each observer was asked to classify the fracture patterns according to the Lauge-Hansen system by class, i.e. supination-adduction (S-A), supination-eversion (S-E), pronation-adduction (P-A) and pronation-eversion (P-E) (*6*). According to the A.O. system, the class and the main subgroups were used, i.e. A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3 (*11*).

In the Broos-Bisschop system there are no classes but symbols synthesized in a title which describes the fracture pattern : (T) characterizes a trimalleolar fracture while (B) and (U) are used for bimalleolar and unimalleolar respectively. (M) corresponds to a medial malleolar, (L) a lateral malleolar fracture, (P) a posterior and (A) an anterior fragment. The Weber classification system is also used, and a small letter following (L) indicates the level of the fibula fracture (a, b, c). For a shaft fracture (f) is used and for the proximal area (p). According to these, the denomination TMLcP translates into : Trimalleolar fracture with fibula damage above the tibiofibular syndesmosis (*3*). The descriptive titles that resulted from each observer were used in the statistical analysis.

Univariate statistical methods, based on absolute and relative frequencies and contingency tables, were applied in order to present the results from the classifications on the radiographs. In order to evaluate the interobserver classification we applied the kappa-coefficient (K-co), which is a chance corrected index of the agreement between the classifications. According to the literature kappa value less than 0.40 characterizes the agreement as "poor", values from 0.40 to 0.80 as "good" and values exceeding 0.80 represent excellent agreement (*6*). A probability value less than 5% was considered significant.

RESULTS

The percentage of unclassified fractures ranged from 8.8% to 12% with the Lauge-Hansen system, from 5.8% to 12% with the A.O. system and from 0.3% to 1.1% with the Broos-Bisschop system (table I).

The agreement between the three raters for the three classification systems is exposed with absolute numbers and percentage in table II.

With the Lauge-Hansen classification system, interrater reliability of the study revealed poor agreement between rater 1 and rater 2 (K-co = 0.316, p-value < 0.001), good agreement between rater 1 and rater 3 (K-co = 0.476, p-value < 0.001) and poor agreement between rater 2 and rater 3 (K-co = 0.174, P-value < 0.001).

With the A.O. classification system, interrater reliability of the study revealed : good agreement between rater 1 and rater 2 (K-co = 0.483, p-value < 0.001), good agreement between rater 1 and rater 3 (K-co = 0.478, p-value < 0.001) and poor agreement between rater 2 and rater 3 (K-co = 0.397, P-value < 0.001).

With the Broos-Bisschop classification system, interrater reliability of the study revealed poor agreement between rater 1 and rater 2 (K-co = 0.383, P-value < 0.001), good agreement between rater 1 and rater 3 (K-co = 0.408, P-value < 0.001) and poor agreement between rater 2 and rater 3 (K-co = 0.327, P-value < 0.001).

All the results (level of agreement between raters, based on Kappa coefficient) are shown in table III.

DISCUSSION

There is no reference in literature on interobserver error of the Broos-Bisschop system. The

Table I. — Unclassified fracture patterns

	Rater 1		Rater 2		Rater 3	
	Number	Percent	Number	Percent	Number	Percent
Lauge-Hansen	26	8.8%	28	9.5%	37	12.0%
A. O.	26	8.8%	17	5.8%	35	12.0%
Broos-Bisschop	2	0.7%	3	1.0%	1	0.3%

Table II. — Agreement between the three raters. L.H. = Lauge-Hansen ; A.O. = Arbeitsgemeinschaft für Osteosynthesefragen ; B.B. = Broos-Bisschop

	L. H.	A. O.	B. B.
Rater 1 vs. Rater 2	147 50%	181 62%	155 53%
Rater 1 vs. Rater 3	214 73%	185 63%	150 51%
Rater 2 vs. Rater 3	114 39%	159 54%	141 48%
Rater 1 vs. Rater 2 vs. Rater 3	97 33%	124 42%	98 33%

Table III. — Level of agreement between raters, based on Kappa coefficient. L.H. = Lauge-Hansen ; A.O. = Arbeitsgemeinschaft für Osteosynthesefragen ; B.B. = Broos-Bisschop

	L. H.	A. O.	B. B.
Rater 1 vs. Rater 2	Poor	Good	Poor
Rater 1 vs. Rater 3	Good	Good	Good
Rater 2 vs. Rater 3	Poor	Poor	Poor
Rater 1 vs. Rater 2 vs. Rater 3	Poor	Poor	Poor

aim of Broos and Bisschop when they presented their own classification system was to address the demands for an ideal classification system as defined by Lindsjö (*2,3,9*). Although the percentage of unclassified fractures is significantly reduced with the Broos-Bisschop classification, the level of concordance between the three raters ranged from 0.327 to 0.408, which is characterized as "poor". It is obvious that the system is based on the A.O. classification system. It is therefore not surprising that the interobserver error of the A.O. system also affects the Broos-Bisschop system.

The overall percentage of unclassified fractures according the Lauge-Hansen system was 10% and this is much higher than reported by other authors (*9*). The considerable percentage of unclassified fractures can be explained by the fact that stages 1 and 2 are similar in pronation-eversion classes (*9*). Another explanation is that the four mechanisms in this system are inadequate to encompass all the possible fracture patterns and this has lead certain researchers to expand the Lauge-Hansen classification system. O'Leary and Ward described the abduction-external rotation mechanism (*13*) while Wilson *et al* described a plantar flexion mechanism (*16*), both resulting in malleolar fractures.

Nielsen *et al* investigating the reproducibility of the Lauge-Hansen system reported poor results (*12*). In this study the level of concordance ranges from 0.174 to 0.476 and is characterized as "poor to good".

Using the A.O. system the overall percentage of unclassified radiographs was 8.7%. This was mainly related with isolated fractures of the medial malleolus. Weber's classification system focuses on the height of the lateral malleolus fracture, and Lindsjö believes this is of value because the lateral

complex is an important element for congruence and stability in the ankle joint (*9*). Later biomechanical and clinical studies showed the medial malleolus as the key for a congruent and stable ankle joint (*1,4*). It is indeed important for a classification system to include the most important element for treatment. Several authors have reported that isolated fractures of the medial malleolus rarely occur (*10,15*). In our study their percentage was about 8.7% and we contend that these fractures are not rare. Broos and Bisschop also found 105 medial unimalleolar fractures in their series (*2*).

We believe that a fourth class in the A.O. system including the isolated avulsion fractures (horizontal, at or below the joint line) of the medial malleolus could significantly reduce the number of unclassified fractures and would increase the concordance rate between different raters. Possible subgroups could involve : (a) Isolated (represents stage 1 in pronation-avulsion and pronation-eversion), (b) with bony flakes anterolaterally and posterolaterally from the tibia (represents stage 2 in pronation-avulsion) and (c) with bony flake anterolaterally from the tibia (represents stage 2 in pronation-eversion).

The overall agreement rates were found to be higher in this system, as the three raters fully agreed in 124/294 (42%) cases, versus 98/294 (33%) and 97/294 (33%) respectively with the Broos-Bisschop and Lauge-Hansen methods.

The level of concordance, as assessed by the Kappa coefficient varies from 0.397 to 0.483 and is characterized as "good". Hoiness and Stromsoe found a "good" concordance rate (K-co = 0.61) using the A.O. system in a study of 50 randomly selected radiographs (*5*), but they recognized that this number is too small to allow any evaluation of observer biases.

The validity of the Lauge-Hansen system is in detection of ligamentous rupture and high fibular fractures. The Broos-Bisschop system has the ability to encompass almost all the possible fractures patterns while the A.O. system has the greater concordance rate between different observers.

According to our results, orthopaedic surgeons interpret differently the malleolar fractures and this results in difficulties to agree on treatment selection. Tile stated that neither the Lauge-Hansen nor the A.O. system can offer appropriate information for the management of malleolar fractures since some of the fractures of one class may require surgery and some others of the same class have a good prognosis without surgery (*15*). To conclude, every classification system has its own advantages but the low reproducibility that results from the high interobserver variability remains a common deficiency, which limits the prognostic value of these classifications and makes comparison between different studies from different authors unreliable. We suggest that further study of ankle fractures is needed in order to provide a valid classification system.

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