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Evaluation of the Reproducibility of the Schatzker Classification Reviewed by Kfuri for Tibial Plateau Fractures

Avaliação da reprodutibilidade da classificação de Schatzker revisada por Kfuri para as fraturas do planalto tibial

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Abstract

Objective The Schatzker classification is the most used for tibial plateau fractures. Kfuri et al.[12] reviewed Schatzker's initial classification describing in more detail the involvement of the tibial plateau in the coronal plane, allowing a better understanding of the fracture pattern and a more accurate surgical planning. The objectives of the present study are to evaluate the interobserver agreement of these classifications and to evaluate the influence of the experience of the observer on the reproducibility of the instruments.

Methods An observational and retrospective study was conducted by evaluating the radiological study of 20 adult individuals with tibial plateau fractures, including radiographs and computed tomography (CT). The fractures were classified once by 34 examiners with varied experience (24 specialists and 10 residents in Orthopedics and Traumatology), according to the Schatzker classification and to the modification proposed by Kfuri. The Fleiss Kappa index was used to verify interobserver agreement.

Results The interobserver agreement index was considered moderate for the Schatzker classification ($\kappa = 0.46$) and mild for the Kfuri modification ($\kappa = 0.30$). The Schatzker classification showed moderate agreement, with $\kappa = 0.52$ for residents and $\kappa = 0.45$ among specialists. The Kfuri classification showed mild agreement, with Kappa values for residents and specialists of 0.39 and 0.28, respectively.

Keywords
- knee joint
- classification
- tibial fractures
- reproducibility of results
- knee injuries

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Conclusion The Schatzker classification and the classification modified by Kfuri presented moderate and mild interobserver agreement, respectively. In addition, the residents presented higher agreement than the specialists for the two systems studied.

Resumo

Objetivo A classificação de Schatzker é a mais utilizada para as fraturas do planalto tibial. Kfuri et al.[12] revisaram a classificação inicial de Schatzker descrevendo com mais detalhes o envolvimento do planalto tibial no plano coronal, permitindo uma melhor compreensão do padrão de fratura e um planejamento cirúrgico mais acurado. Os objetivos do presente estudo são avaliar a concordância inter-observador dessas classificações e avaliar a influência da experiência dos observadores na reprodutibilidade dos instrumentos.

Métodos Foi realizado um estudo observacional e retrospectivo, por meio da avaliação do estudo radiológico de 20 indivíduos adultos com fraturas do planalto tibial, incluindo radiografias e tomografia computadorizada (TC). As fraturas foram classificadas 1 vez por 34 examinadores com experiência variada (24 especialistas e 10 residentes em Ortopedia e Traumatologia), de acordo com a classificação de Schatzker e com a modificação proposta por Kfuri. O índice Kappa de Fleiss foi usado para verificar a concordância interobservadores.

Resultados O índice de concordância inter-observador foi considerado moderado para a classificação de Schatzker ($\kappa = 0{,}46$) e leve para a modificação de Kfuri ($\kappa = 0{,}30$). A classificação de Schatzker apresentou concordância moderada, com $\kappa = 0{,}52$ para residentes e $\kappa = 0{,}45$ entre os especialistas. A classificação de Kfuri apresentou concordância leve com valores de Kappa para residentes e especialistas de 0,39 e 0,28, respectivamente.

Conclusão A classificação de Schatzker e a classificação modificada por Kfuri apresentaram concordância interobservadores moderada e leve, respectivamente. Além disso, os residentes apresentaram concordâncias superiores aos especialistas para os dois sistemas estudados.

Palavras-chave
- articulação do joelho
- classificação
- fraturas da tíbia
- reprodutibilidade dos testes
- traumatismos do joelho

Introduction

Tibial plateau fractures are relatively common lesions, representing between 1 and 2% of all fractures in the human body.[1] These fractures are due to the application of axial compressive forces combined or not with varus or valgus stress in the knee joint.[2] Factors such as the degree of energy applied, direction of strength, knee position, and bone quality of the patients are determining factors for the personality of the fracture and its degree of deviation.[1,3] Because tibial plateau fractures have joint involvement, they represent a risk for knee function; aiming, therefore, whenever possible, at anatomical reduction of the articular surface and stable fixation to allow early mobilization. Thus, it is essential to adequately understand the characteristics of the fracture for the definition of the surgical approach.[4,5]

Classifications are important tools that can define prognosis and assist in decision-making of the most appropriate treatment. At least 38 systems have been described to classify tibial plateau fractures.[6] Some studies have verified the reproducibility of these classifications, concluding that both inter- and intraobserver analyses have low to moderate agreement.[6–10] A previous study pointed out that the available systems have difficulty in classifying fractures involving the posterior region of the tibial plateau.[7] The most used classification among orthopedic surgeons is that of Schatzker, originally proposed in 1974.[11] This system is based on biplanar images, describing six possible types of fracture. In 2018, Kfuri et al.[12] reviewed the Schatzker classification by adding three-dimensional (3D) evaluation with the aid of tomographic reconstruction. This tool aims to describe in more detail the involvement in the coronal plane, allowing a better understanding of the fracture pattern, and a more appropriate surgical planning, since this classification helps in the indication of the most appropriate access route, especially for fractures encompassed in types V and VI.

Previous studies evaluating the agreement of different classifications of tibial plateau fractures vary greatly in relation to the number of cases and evaluators. For example, a previous study included 3 observers,[13] and another included 81 observers,[14] reporting similar results with mild agreement for the Schatzker classification. These results could represent that including few or a very high number of observers could

lead to a reduction in the agreement of the classifications. As far as we know, only Castiglia et al.[15] evaluated the reproducibility of the Schatzker[11] classification and the classification modified by Kfuri et al.[12] In this study, 10 evaluators classified 70 tibial plateau fractures, reporting moderate interobserver agreement for both systems, using the Cohen Kappa coefficient.

Thus, to confirm and expand the results previously found,[15] we conducted a study evaluating tibial plateau fractures, including a larger number of evaluators. The objectives of the present study are to evaluate the interobserver agreement of the Schatzker classification[11] and of the modification proposed by Kfuri et al.,[12] and the influence of the technical experience of the observers on the degree of reliability of the evaluations.

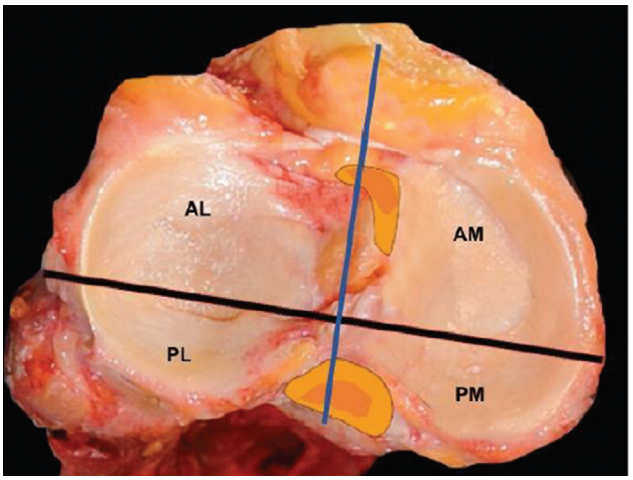

Fig. 2 Cadaveric part photography of the tibial plateau with the virtual equator traced dividing the articular surface into two posterior and anterior hemispheres. Legend: AL, anterolateral; PL, posterolateral; AM, anteromedial; PM - posteromedial. (Reproduced from Castiglia MT.[15] Complementação tomográfica da classificação de Schatzker para as fraturas do planalto tibial [tese]. Ribeirão Preto. Faculdade de Medicina de Ribeirão Preto; 2017).

Material and Methods

This is an observational and retrospective study in which radiographic and tomographic images obtained from patients with fractures of the proximal region of the tibia treated in 2019 were analyzed. Patients of both genders, aged > 18 years old, diagnosed with tibial plateau fracture in previously healthy bone and submitted to conservative or surgical treatment were included in the study. The present study was approved by the Research Ethics Committee of the Institution under no. 15827019.0.0000.0023 .

The diagnosis of fractures was made through radiographs at anteroposterior (AP) and lateral projections and computed tomography (CT) of the knee with 3D reconstruction and subtraction of the proximal femur and patella. The exclusion criteria were: previous fracture of the tibial plateau, lack of a complete radiological study or quality considered as insufficient.

For each patient, a PowerPoint (Microsoft Corp., Redmond, WA, USA) slide sequence was created with a group of images composed of two radiographs in orthogonal, AP and lateral projections, as well as with CT images in axial, sagittal, and coronal projections, and 3D reconstruction of tomographic images of the proximal tibia. The set of slides of the patients included formed a presentation that was shown to the evaluators.

The evaluators were orthopaedic surgeons with different levels of experience in the area, being 24 members of the Brazilian Society of Orthopedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia [SBOT, in the Portuguese acronym]), considered "specialists", orthopaedic surgery residents (1 trainee in knee surgery; 3 3rd-year residents, 4 in the 2nd year, and 2 in the 1st year of Orthopedics and Traumatology). To assess the interobserver agreement, the 34 evaluators classified fractures only once by the two systems described, after a brief explanation and demonstration of illustrative figures with the Schatzker[11] classifications and their modification proposed by Kfuri et al.[12] The participants were allowed to consult the classifications at any time (►**Figures 1** and **2**). The degree of influence of the experience of the observers was evaluated by the agreement of the evaluations of the specialists and residents, alone.

Classification Systems

The Schatzker classification[11] describes six types of injury: Type I, shear of the lateral plateau; Type II, shear associated with lateral plateau depression; Type III, isolated depression of the lateral plateau; Type IV, isolated fracture of the medial plateau; Type V, bicondilar fracture with some preservation of bone continuity with diasphysis; Type VI, decoupled bicondilar fracture of the diasphysis (►**Figure 1**).

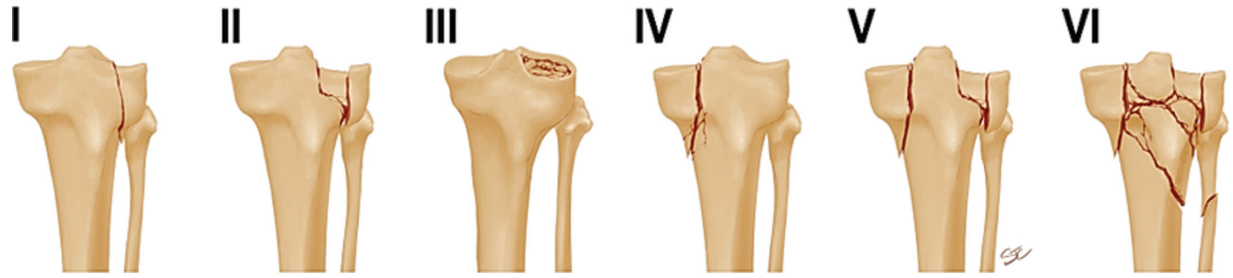

Fig. 1 Schatzker classification for tibial plateau fractures.

In the classification modified by Kfuri et al.,[12] the six types described by Schatzker remain, but modifiers "A" to anterior, and "P" to posterior were added, delimiting four distinct anatomical areas, specifically the anterior medial, anterior lateral, posterior medial and posterior lateral. The division of the articular surface of the tibial plateau is performed by a virtual equator, which divides the tibial plateau into two hemispheres, posterior and anterior. The anatomical references for the creation of this virtual equator are, laterally, the insertion of the lateral collateral ligament in the head of the fibula and, medially, the posterior insertion line of the fibers of the superficial medial collateral ligament near the medial tibial crest (►**Figure 2**).

Statistical Analysis

The statistical analysis of the obtained results was performed using the Fleiss Kappa test to evaluate the interobserver agreement for the Schatzker classifications and of its modification by Kfuri. The results of the evaluations were also analyzed by groups of observers, specialists and residents. The Kappa coefficient is the most common statistical analysis method present in many articles that assess the agreement between two examiners (or two methods). Fleiss[16] proposed a Kappa extension for when there are more than two examiners (or methods). Thus, the use of the Fleiss Kappa coefficient is considered the most appropriate when faced with the situation in which multiple examiners or evaluations are made, and when the evaluated scale presents many categories. Its value ranges from + 1 (perfect agreement), goes through 0 (agreement equal to chance) and down to - 1 (complete disagreement).[17,18]

There are no definitions regarding the accepted levels of agreement, but Landis et al.[19] proposed the following interpretation: results between 0 and 0.19 present a poor agreement; between 0.2 and 0.39 present a mild agreement; between 0.4 and 0.59 present a moderate agreement; between 0.6 and 0.79 present a substantive agreement; and a value > 0.80 is considered as almost perfect agreement. The criterion level adopted for the determination of significance was of 5%. Statistical analysis was processed by the statistical software SAS System, version 6.11 (SAS Institute, Inc., Cary, NC, USA).

Results

The interobserver agreement index was considered moderate for the Schatzker classification ($\kappa = 0.46$), and mild for Kfuri modification ($\kappa = 0.30$).

When analyzing the classifications according to the level of experience of the evaluator (specialists versus residents), we observed concordance indexes with similar interpretations, but with higher values in the group of residents. The Schatzker classification showed moderate agreement, with $\kappa = 0.52$ for residents and $\kappa = 0.45$ among specialists. The Kfuri classification showed mild agreement, with Kappa values for residents and specialists of 0.39 and 0.28, respectively (►**Table 1**). ►**Table 2** describes the results of the evaluations of tibial plateau fractures of the 20 patients by the 34 examiners.

Discussion

Several studies have investigated the reliability of fracture classifications involving the tibial plateau in an attempt to define which system has the ability to assist in treatment decision making.[6–12] However, agreement values considered low to moderate for inter- and intraobserver analysis are reported.[6–10] The main findings of the present study show that the Schatzker classification showed moderate interobserver agreement, while the Schatzker classification modified by Kfuri showed mild agreement. Moreover, differently than we expected, the residents presented greater interobserver agreement for the two classifications.

The recent Schatzker classification modified by Kfuri et al.[12] proposes detailing the pattern of tibial plateau fractures, allowing a better understanding and surgical planning through the choice of the most appropriate access route. In our study, the Schatzker classifications and the one proposed by Kfuri presented Kappa values of interobserver agreement interpreted as moderate and mild, respectively. These results partially confirm and expand the findings of the study conducted by Castiglia et al.[15] In the only study that evaluated the agreement of the Kfuri classification, these authors reported higher Kappa values than ours, with a substantial and moderate coefficient of agreement for the same instruments, respectively. We believe that this difference was due to some reasons: sample size with 20 cases, difference in training and experience of the evaluators, and the inclusion of only X-ray and CT images of the fractures, while in the other study were made available to observers, in addition to X-ray images, videos with all planes and CT reconstructions. Both situations may have acted by decreasing both inter and intraobserver agreement. The instrument described by Kfuri, despite allowing a more detailed evaluation of fractures, offers a greater number of classification possibilities, increasing its complexity.[12,15] In agreement with our study, Castiglia et al.[15] described superior reliability of the Schatzker classification in relation to its modification. Previous studies have observed that more complex systems for the classification of fractures present lower interobserver agreement due to the greater number of options for the evaluators.[20,21] We observed greater agreement in the most complex cases, involving the four anatomical areas of the tibial plateau, as well as in less complex fractures, involving a single area. However, due to the limited sample size of the present study, this information should be considered with restrictions.

The Schatzker classification[11] is the most used among orthopedic surgeons; consequently, most evaluators are familiar with it. Taking this classification into account, we observed a moderate agreement among the observers. These results are supported by the literature, which presents similar results, with mild to moderate agreement.[6–10,13,21–24] Since CT is indispensable for the application of the Kfuri classification, in our study, the evaluators used tomographic and radiographic images to classify by the Schatzker system. The importance of using CT to increase the reliability of the Schatzker classification is still unclear.[25] Some studies investigated the agreement only including X-ray images, with similar results.[8,9,13,22] A study

Table 1 Result of the evaluation of tibial plateau fractures ($n = 20$) by 34 observers according to the Schatzker classification and to the modification proposed by Kfuri

Evaluator	Patient 01		Patient 02		Patient 03		Patient 04		Patient 05		Patient 06		Patient 07		Patient 08		Patient 09		Patient 10	
	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri	Schatzker	Kfuri
1	1	AP	4	AP	3	P	2	AP	4	AP	2	A	6	P.M	5	AM + PM	6	AL + PL + AM + PM	5	AL + AM + PM
2	2	P	5	AM + AL + PL	2	P	4	AP	5	AM + AL + PL	2	A	3	AP	2	AP	6	AM + AL + PL	5	AM + AL + PL
3	1	P	4	A	3	P	2	P	5	PL + AM	2	A	3	A	1	A	5	PM + PL + AM	5	PM + PL
4	2	P	5	PL + AL + AM + PM	1	P	4	AP	4	AP	2	A	3	AP	5	AM + AL + PL	5	AM + PM + PL	5	AL + PL + PM
5	1	AP	5	AL + PL + AM	2	P	1	P	5	AM + PL	2	A	3	A	1	AP	6	AM + PL	1	P
6	1	AP	5	AM + PL + AL	2	AP	4	AP	6	AM + PM + AL	2	AP	2	AP	5	AL + PL + AM + PM	6	AM + PL	5	PL + AL
7	2	P	5	PL + AM	1	P	5	PM + PL	4	AP	1	A	3	P	1	AP	6	AL + PL + PM + AM	5	AL + PL + PM
8	2	P	5	AL + PL + PM	3	P	4	P	6	AL + PM + AM	2	A	3	A	2	A	6	PL + AM + PM	5	AL + PL + PM
9	1	P	6	PM + PL	1	P	4	AP	4	AP	2	A	2	A	6	PL + AL	6	PL + PM + AM	5	PM + AL + PL
10	2	AP	5	AM + PM + AL + PL	3	P	4	P	4	P	2	A	3	P	1	AP	4	AP	5	AL + PL + PM
11	5	PL + PM	4	AP	3	P	4	P	4	AP	2	A	3	A	2	AP	5	PL + AM + PM	5	PL + PM
12	2	P	4	AP	1	AP	4	AL + AM + PM	5	AL + AM + PL + PM	2	A	3	A	2	A	6	AM + AL + PL	2	AP
13	1	P	1	AP	1	P	4	AP	4	AP	2	A	3	A	2	A	4	AP	5	PM + AL + PL
14	5	AL + PL + PM	5	AM + PM + AL	3	P	4	AP	5	AM + PM + AL	2	A	3	AP	2	AP	6	AM + PM + AL + PL	5	AM + PM + AL + PL
15	3	P	5	PM + AL	3	P	4	AP	4	AP	2	A	3	A	6	AM + AL	6	PL + PM + AM	3	P
16	2	AP	5	AL + PL	1	P	1	P	5	PL + AM	3	A	3	P	5	AL + PL	6	AL + PL + AM + PM	6	PM + PL + AM
17	5	PL + PM	5	PL + AL + PM + AM	3	P	4	P	5	AL + AM + PM	2	A	3	A	2	AP	4	AP	5	AM + AL + PL
18	1	P	4	AP	3	P	4	P	4	AP	2	A	3	P	2	A	6	AM + PL	2	P
19	1	P	6	AL + AM + PL	3	P	4	P	5	AL + PL + AM	2	AP	3	P	4	AP	4	AP	5	AL + PM + PL
20	2	P	5	AM + AL + PL	1	P	4	P	5	AM + PL	2	A	3	P	1	A	6	AM + AL + PL	2	AP
21	2	AP	5	AL + PL + AM + PM	3	P	4	AP	4	AP	2	A	3	AP	1	AP	5	PL + AM + PM	5	AL + PL + PM
22	1	P	4	AP	2	P	4	P	4	AP	2	A	3	P	1	A	4	AP	5	AL + PL + PM
23	1	AP	5	P.M	3	P	4	P	6		2	A	3	AP	1	AP	6		6	

Table 1 (*Continued*)

Evaluator	Patient 01		Patient 02		Patient 03		Patient 04		Patient 05		Patient 06		Patient 07		Patient 08		Patient 09		Patient 10	
										AL + PL + PM								PL + PM + AM		AL + PL + PM
24	2	P	5	AM + AL + PL	2	P	4	P	4	A	2	A	3	A	6	AL + PL	4	AP	2	AP
25	2	AP	5	AL + AM	3	P	4	P	4	AP	2	A	2	P	2	AP	6	AM + PM + PL	2	AP
26	1	P	4	AP	3	A	4	P	5	AL + PM	2	A	3	A	6	AL	6	AL + AM + PM + PL	2	AP
27	1	P	5	PL + PM + AL	1	P	4	AP	5	AM + PM + PL	2	A	3	AP	2	A	6	PM + AM + PL	2	AP
28	1	P	4	AP	3	P	4	AP	5	AM + PM + PL + AL	2	A	3	AP	2	AP	6	AM + PM + AL + PL	5	AL + PL + AM + PM
29	1	P	5	AM + PM + AL + PL	3	P	4	AP	5	AM + PM + AL	2	A	3	A	2	AP	6	AM + PM + AL + PL	5	PM + AL + PL
30	1	AP	4	AP	2	P	4	AP	4	AP	2	A	3	AP	6	AL + PL	6	AM + PM	2	AP
31	2	AP	4	AP	3	P	4	AP	5	AM + PM + AL + PL	2	A	2	AP	5	AL	5	AM + PM	2	AP
32	2	AP	4	AP	3	P	4	P	1	AP	2	A	3	AP	2	AP	5	AL + PL+ PM	3	AP
33	1	P	4	AP	3	AP	4	P	4	AP	2	A	3	AP	1	A	4	AP	6	AM + PM + AL + PL

(*Continued*)

Table 1 Result of the evaluation of tibial plateau fractures ($n = 20$) by 34 observers according to the Schatzker classification and to the modification proposed by Kfuri

Evaluator	Patient 11		Patient 12		Patient 13		Patient 14		Patient 15		Patient 16		Patient 17		Patient 18		Patient 19		Patient 20	
	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri	Schat-zker	Kfuri
1	6	AL + PL + AM + PM	2	AP	2	A	5	AL + AM + PL + PM	4	AP	6	AL + PL	2	AP	4	AP	2	P	1	AP
2	6	AM + AL + PM + PL	1	A	2	A	6	AL + PL + PM	5	AM + AL	5	AL	2	AP	5	AL + PL + AM + PM	2	AP	2	AP
3	6	AM + AL + PM + PL	2	A	1	A	6	AM + AL + PM	5	PL + AM	5	AM + PM	2	AP	5	PM + PL + AL	2	AP	2	AP
4	6	AL + PL + AM + PM	1	A	2	A	5	AL + PL + AM + PM	5	AL + PL + AM	2	AP	2	AP	5	AL + PL + PM	2	AP	2	AP
5	6	AM + PM + PL + AL	1	AP	1	A	5	AL + PL + PM	5	AL + PL + AM	6	AL	1	AP	5	AM + AL + PM + PL	1	AP	1	AP
6	6	AL + PL + AM + PM	1	AP	2	AP	6	AL + PL + AM + PM	5	AL + PL + AM	6	AM + PL	2	AP	5	AM + AL + PL + PM	2	AP	2	AP
7	6	AL + PL + AM + PM	1	AP	1	A	6	AL + PL + AM + PM	6	AM + AL + PL	6	AL	3	P	6	AL + PL + PM	2	P	2	AP
8	6	AL + PL + AM + PM	1	A	2	A	6	AL + PL + AM + PM	6	AL + PL + PM	1	AP	2	AP	5	AL + PL + PM	2	AP	2	AP

(*Continued*)

Table 1 (*Continued*)

Evaluator	Patient 11		Patient 12		Patient 13		Patient 14		Patient 15		Patient 16		Patient 17		Patient 18		Patient 19		Patient 20	
9	6	AL + AM + PL + PM	1	A	2	A	6	PM + PL + AL + AM	6	PM + PL + AL + AM	6	AL	1	AP	6	PM + PL + AM + AL	2	P	2	AP
10	6	AL + PL + AM + PM	1	A	2	A	6	AL + PL + AM + PM	5	AL + PL + PM	1	A	1	AP	5	AL + PL + AM + PM	2	AP	5	AL + PL + PM
11	6	AL + AM + PL + PM	1	A	3	A	6	AL + PL + AM + PM	5	AL + AM	5	AL + AM	2	AP	5	AL + PL + PM	3	AP	3	AP
12	6	AL + AM + PM + PL	1	A	2	A	6	AL + AM + PM + PL	5	AM + AL + PL	6	AL	1	AP	6	AL + AM + PL + PM	2	AP	1	AP
13	6	AM + PM + AL + PL	1	A	1	A	6	AM + AL + PM + PL	5	PL + AM	6	AL + AM + PM	1	A	6	AL + PM + PL	2	AP	2	AP
14	6	AM + PM + AL + PL	1	A	3	A	6	AM + PM + AL + PL	6	AM + PM + AL + PL	6	AL	1	AP	6	AM + PM + AL + PL	2	AP	2	AP
15	6	AM + PM + AL + PL	2	A	2	A	6	AM + PM + AL + PL	6	AM + PM + PL + AL	6	AL + AM	1	AP	6	AL + PL + AM + PM	2	AP	2	AP
16	6	AL + PL + AM + PM	2	A	2	A	6	AL + PL + AM + PM	6	PL + AM	5	AL	1	A	5	AM + AL + PM + PL	3	P	1	A
17	6	AM + PM + AL + PL	2	A	2	A	6	AL + AM + PL + PM	6	AL + AM + PL + PM	5	AL + PL + PM	2	AP	5	AL + PL + PM	2	AP	2	AP
18	6	AM + AL + PM + PL	1	A	2	A	6	AM + PM + AL + PL	5	AM + PL	1	P	1	AP	5	AM + AL + PL	3	P	1	AP
19	6	AL + AM + PL + PM	2	AP	2	A	6	AL + AM + PM	5	AM + PM + PL	6	AL + PL	2	AP	5	AL + AM + PL + PM	2	P	1	AP
20	6	AL + PL + PM	1	A	3	A	6	PM + PL + AL	5	AM + AL + PL	6	AL	1	AP	5	AM + AL + PL	2	AP	1	AP
21	6	AL + PL + AM + PM	2	A	2	AP	6	AL + PL + AM + PM	6	AL + PL + AM + PM	1	AP	1	AP	6	AL + PL + AM + PM	2	P	1	AP
22	6	AL + PL + AM + PM	1	AP	1	A	6	AL + AM + PM	6	AL + PL + PM	1	A	1	AP	6	AL + PL + PM	2	P	1	AP
23	6	AL + PL + AM + PM	1	AP	1	AP	6	AL + PL + AM + PM	6	AL + PL + AM + PM	6	AL	1	AP	6	AL + PL + AM + PM	2	AP	2	AP
24	6	AL + PL + AM + PM	1	A	2	A	6	AL + AM + PM	6	PL + AM + PM	5	AL	1	A	5	AL + PL + AM + PM	2	AP	2	AP
25	6	AL + PL + AM + PM	1	AP	1	A	6	AL + PL + AM + PM	6	AL + AM + PM	4	AP	1	AP	5	AL + PL + AM + PM	2	P	1	A
26	6	AL + AM + PM + PL	1	A	1	A	5	AL + AM + PM + PL	5	AL + AM + PL + PM	4	P	1	AP	5	AL + PM	2	AP	2	AP
27	5	AM + AL + PM + PL	3	A	2	A	5	AM + PM + AL + PL	5	AM + PM + PL	6	AL	1	AP	5	PL + AL + PM	2	P	2	AP
28	6	AM + PM + AL + PL	2	AP	3	A	6	AM + PM + AL + PL	5	AM + PM + AL + PL	4	A	2	AP	5	AL + PL + PM	2	AP	2	AP
29	6	AM + PM + AL + PL	2	A	3	A	6	AM + PM + AL + PL	5	AM + PL + AL	5	AL + PM	2	AP	5	AL + PL + PM	2	AP	2	AP
30	5	AL + PL + AM + PM	1	A	3	A	5	AM + PM + AL + PL	5	AM + AL + PL	6	AL + PL	1	AP	5	AM + PM + AL + PL	2	AP	2	AP
31	6		1	AP	2	A	6		6	PM + PL	6	AL	1	AP	6	AL + PL	2	AP	2	AP

Table 1 (*Continued*)

Evaluator	Patient 11		Patient 12		Patient 13		Patient 14		Patient 15		Patient 16		Patient 17		Patient 18		Patient 19		Patient 20	
		AM + AL + PM + PL						AM + PM + AL + PL												
32	6	AL + PL + AM + PM	1	A	2	A	6	AL + PL + AM + PM	5	AL + PL + AM	1	A	1	AP	5	AL + PL + PM	2	AP	2	AP
33	6	AM + AL + PM + PL	1	A	2	A	6	AM + PM + AL + PL	5	AM + PL	4	A	1	AP	5	PM + PL + AM + AL	2	AP	1	AP
34	6	AL + PL + AM + PM	2	A	2	A	6	AL + AM + PL + PM	5	AL + AM + PL + PM	6	AL + PL	2	AP	5	AL + PL + PM	2	AP	1	AP

Abbreviations: A, anterior; AL, anterolateral; AP, anteroposterior; AM, anteromedial; P, posterior; PL, posterolateral; PM, posteromedial.

Table 2 Interobserver agreement ($n = 34$) of the Schatzker classification system and of the Kfuri modification for 20 tibial plateau fractures

Classification	Interobserver agreement (κ)		
	General	Level of experience	
		Experts	Residents
Schatzker	0.46	0.52	0.45
Kfuri Modification	0.30	0.39	0.28

κ - Kappa de Fleiss.

evaluating 50 tibial plateau fractures only with X-ray and, later, with X-ray and CT, showed that there were no differences in relation to reproducibility.[23] However, other studies have shown a significant increase in Kappa values for the diagnosis of fractures after the inclusion of CT, especially of 3D images.[15,21,25,26] A recent study investigated the effect of the addition of 3D tomographic images on the classification of tibial plateau fractures, concluding that the addition of the third dimension did not improve the reproducibility of the system; in fact, the use of 2D images alone had higher agreement.[14] Although the role of CT in the inter- and intraobserver agreement of tibial plateau fractures still needs to be determined,[24] this tool proved to be fundamental in choosing the surgical access route, especially in lesions with coronal orientation.[15,27]

Previous studies evaluating tibial plateau fractures reported that the experience of the observers did not influence the degree of reliability of the classifications.[9,13,14,21] Interestingly, in the present study with 34 observers, 24 "specialists" and 10 residents, we observed that interobserver agreement was higher among the less experienced ($\kappa = 0.52$ and 0.39) in relation tospecialists ($\kappa = 0.45$ and 0.28), for the Schatzker classification and for the modification by Kfuri, respectively. The modification by Kfuri was recently published and is not yet widely disseminated even among experts. Moreover, the explanation made by the authors prior to the evaluation by the participants may have left doubts about the correct application of the system, a fact that may justify the greater agreement among residents who used illustrative figures more often. Corroborating our hypothesis, Sacramento et al.[20] studied patients with ankle fracture, demonstrating that residents had greater inter- and intraobserver agreement for the classifications of Danis-Weber, Lauge-Hansen and group A.O. (Arbeitsgemeinschaft für Osteosynthesefragen), suggesting that less experienced observers probably used more of the images of the classifications available as feedback.

We are aware of the limitations of the present study. Among them, we can mention the lack of evaluation of intraobserver agreement, and the evaluation of the agreement of the different imaging exams, that is, X-ray and CT, separately. In addition, the number of observers and cases/fractures studied differed from most of the previously published studies, especially in the single study that evaluated the system proposed by Kfuri,[15] which included 70 cases evaluated by 10 observers. The sample size may have been an important factor for the low agreement observed, since this may have underestimated the heterogeneity of the possible fracture patterns for the tibial plateau. Finally,

we made available only part of the CT images; therefore, as the observer could not evaluate the entire set of images, the section presented might not be fully representative of the fracture. However, in a recent study, the evaluators had access to 2D and 3D CT videos, showing lower concordance values than ours for the Schatzker classification.[14]

Conclusion

The Schatzker classification and the classification modified by Kfuri showed moderate and mild interobserver agreement, respectively. In addition, the residents presented higher agreements with the specialists for the two systems studied.

Authors' Declaration of Contribution

Each author contributed individually and significantly to the development of the present article. Mansur H. (0000–0001–7527–969X): data collection, data analysis, writing and revision of the article, all intellectual concept of the article, preparation of the entire research project; VLBC (0000–0003–3236–4813): data collection, article writing and article review; Abdo B. (0000–0001–5269–9106): data collection, data analysis; Ramos L. S. (0000–0002–7233–796X): writing and revision of the article; Castiglia M. T. (0000–0001–7543–2199): article review.

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Conflict of Interests

The authors have no conflict of interests to declare.

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