



## Two column classification of tibial plateau fractures; description, clinical application and reliability

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### ABSTRACT

**Purpose:** In this era of life highly comminuted and multi planar tibial plateau fractures involving the posterior corners are more commonly seen and addressed in the literature than before. Among these several types have not been described in the currently used classification systems. In fact simple classification systems ignore several fracture types and leniently grouped the fractures with different mechanism, morphology, treatment modalities and prognosis in same category. On the other hand, more extensive nature classifications with detailed subdivisions are difficult to remember for clinicians. The clinical reliability of these classifications is another problem. All these issues demand the potential need of a new classification. The aim of this study was to describe a quadrant specific two column classification of tibial plateau fractures and to analyse its inter-observer and intra-observer reliability, clinical assessment and application.

**Materials and methods:** From January 2009 to December 2015, 44 patients with tibial plateau fractures were studied retrospectively. The antero-posterior (AP), lateral X-rays and computed tomography (CT) with axial transverse, sagittal, coronal and three dimensional (3D) reconstruction images were performed for all the patients. All of the fractures were categorized according to quadrant specific two column classification and the traditional Schatzker's classification. The comparative analysis for inter-observer and intra-observer reliability of the new classification and the Schatzker's classification was conducted by four observers.

**Results:** Three cases didn't match any type in the Schatzker's classification. While on the other hand, all cases were classified by two column classification. The mean kappa values for inter-observer reliability by using the Schatzker's classification was 0.723 (range, 0.674-0.823), representing substantial agreement, whereas the mean kappa value was 0.939 (range: 0.897-0.974), representing almost perfect agreement according to two column classification. The mean kappa values for intra-observer reliability using the Schatzker's classification and two column classification were 0.789 (range: 0.590-0.864) and 0.955 (range:0.923-0.948) showing substantial agreement and almost perfect agreement.

**Conclusion:** The quadrant specific two column classification is anatomically oriented, CT based and clinically valid. The different fracture types according to anatomic location are represented alphanumerically so that treatment matched to specific fracture type (quadrant specific anatomic fixation) for optimal outcomes. Furthermore, it demonstrates higher inter-observer and intra-observer reliability. This classification can be adopted to strengthen the traditional Schatzker's classification,

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particularly in the multi planar and posteriorly extended plateau fractures. It can be used as a reliable research tool. The database can be used to distinguish different fracture types, individual type incidences, specific treatment and also prognosis. Authors suggest a large multi-centre study.

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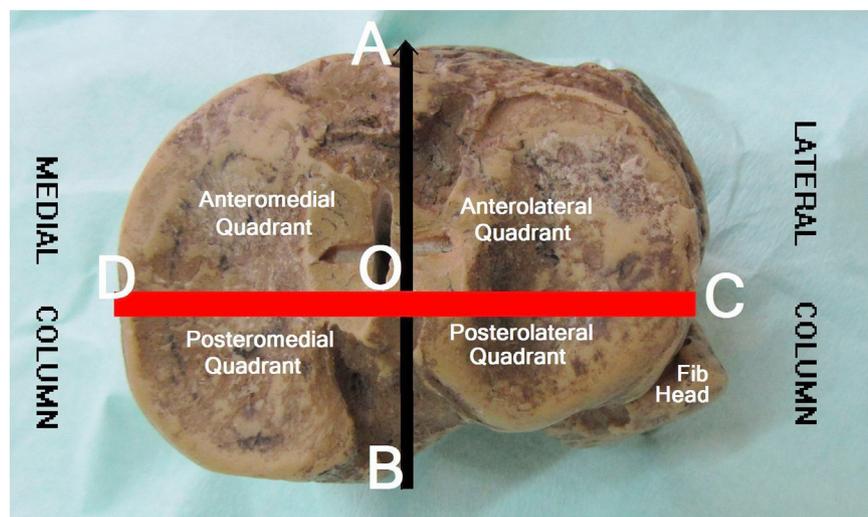
## Introduction

Tibial plateau fractures are diverse in complexity. These pose a challenge to the operating surgeon and are technically demanding due to intra articular nature, specific fracture personality and concomitant soft tissues devitalisation [1,2]. These fractures range from low energy lateral plateau fractures which are comparatively easy to treat with good clinical outcomes to high energy bicondylar fracture patterns with high outcomes of post traumatic arthritis [3]. Mechanism of injury varies from varus, valgus impact, axial loading or combination of these. Knee position at time of injury is also critical to determine the fracture pattern and morphology besides the force direction and the magnitude of trauma [4,5]. A detailed step wise workup is essential. Pre operative planning, selection of approach in convenient posture and finally anatomic fracture reduction and fragment specific fixation are mandatory for good prognosis [6]. There are several classifications described for tibial plateau fractures, [1,6–17] among these the Schatzker and AO/OTA classifications are mostly used in recent clinical practice. The currently used classification systems are solely based on plain radiography [18]. AP (antero-posterior) radiographs which show only two dimensional details are unable to analyse the essential features of a three dimensional structure (tibial plateau). Furthermore, several types of the tibial plateau fractures are not described properly while others like as posterior plateau fractures in coronal plane are not duly appreciated in contemporary classification systems. These coronal plane deformities may be an isolated injury as posteromedial split, posterolateral split or the part of an anterior unicondylar or bicondylar fracture type. Literature review shows a significant percentage of these fractures [19,20]. The recent surgical consensus shows anatomic reduction and fixation of articular surface to minimise the incidences of post traumatic arthritis [21]. Therefore, complete understanding of the fracture pattern is essential for optimal

preoperative planning. Simple split fractures, depression type fractures or depression alone of medial condyle are different lesions demanding different treatment strategies and show different prognosis clinically. These should be classified separately just as lateral condyle but all of them are grouped together leniently as Schatzker type IV. So, Schatzker's classification does not obey a definite criterion. These facts imply the need of a detailed classification scheme which should be simple to use clinically. Imaging modalities are a key to understand the complex intra articular geometry of fracture. Refined imaging modalities for example computed tomography (CT), and magnetic resonance imaging (MRI) have been used to supplement plain radiographs in evaluating tibial plateau fractures and concomitant ligamentous injuries [22,23]. Three dimensional reconstruction CT shows excellent three dimensional detail and delineate features of the tibial plateau. Dias et al. [24] recognized the benefits of CT scan when compared with plain films and standard tomographs. We are proponent of CT based column concept and divide tibial plateau anatomically into two columns medial and lateral column which are further subdivided into anterior and posterior halves. Significance of the quadrants lies in specific quadrant fixation for anatomic reduction and fixation and also its simplicity. The potential pitfall in three column classification is the lack of essential detail about morphology (type) and the severity of fractures is described in our classification system.

## Materials and methods

44 consecutive cases of tibial plateau fractures comprising 37 males and 7 females were studied retrospectively between January 2009 and December 2015. The mean age of the patients was 46.5 years (range, 21–72 years). The most common mode of injury was a road traffic accident followed by falls from height. Plain radiographs and CT scans were obtained using the Picture Archiving and Communication System database (PACS). Difficulty encountered



**Fig. 1.** The anatomical specimen of tibial plateau representing the classification divisions. O: middle point of tibial spines A: medial 1/3rd of tibial tuberosity. B: posterior sulcus C: anterior surface of fibular head. D: postero-medial border.

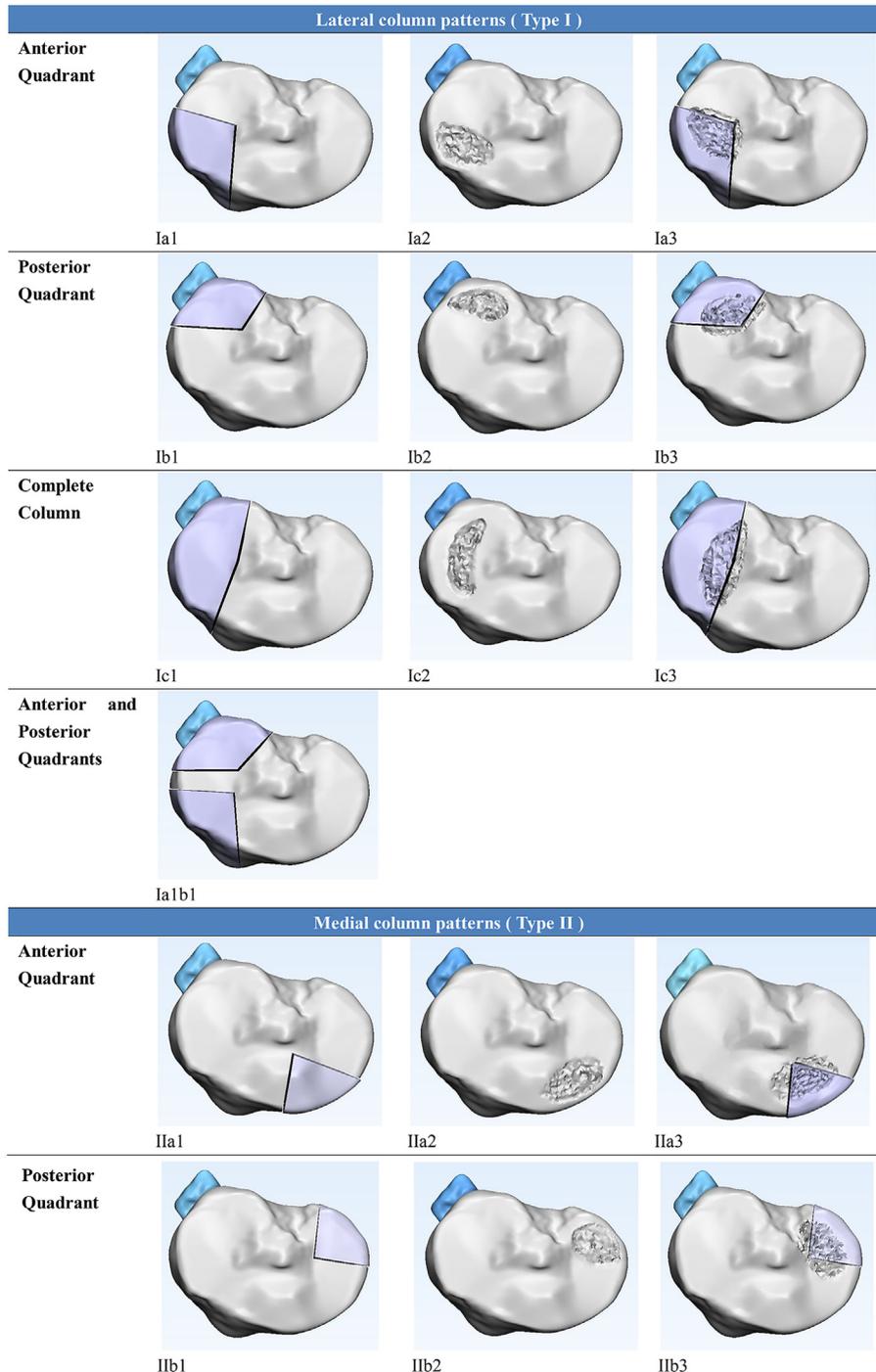
**Table 1**  
Nomenclature of four quadrants.

Name of Quadrant	Nomenclature
Anterolateral quadrant (ALQ)	Ia
Posterolateral quadrant (PLQ)	Ib
Anteromedial quadrant (AMQ)	IIa
Posteromedial quadrant (PMQ)	IIb
Complete lateral column	Ic
Complete medial column	IIc
Both column involvement and fracture line extends to diaphysis	III

while classifying most of these cases using the Schatzker's classification. The solution of this difficulty led to the evolution of a new classification.

*Description of classification*

The tibial plateau anatomically can be divided into medial and lateral columns by a vertical line AB passing through the central point O. Point A is medial 1/3rd of tibial tuberosity and point B is at posterior sulcus of tibia. Each column further subdivided into anterior and posterior half by a horizontal line CD. Point C is the



**Fig. 2.** Illustrations showing different types of fractures.

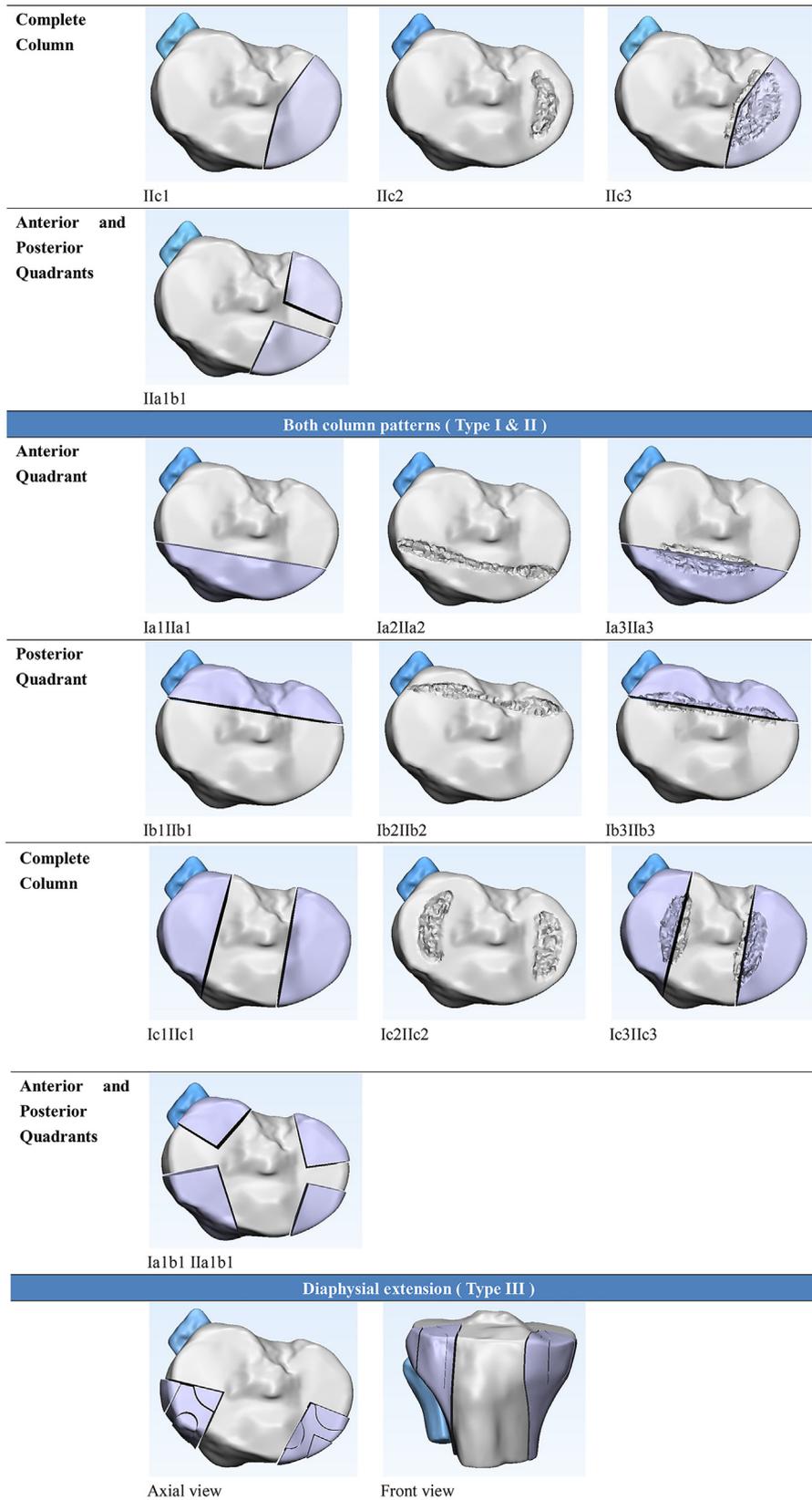


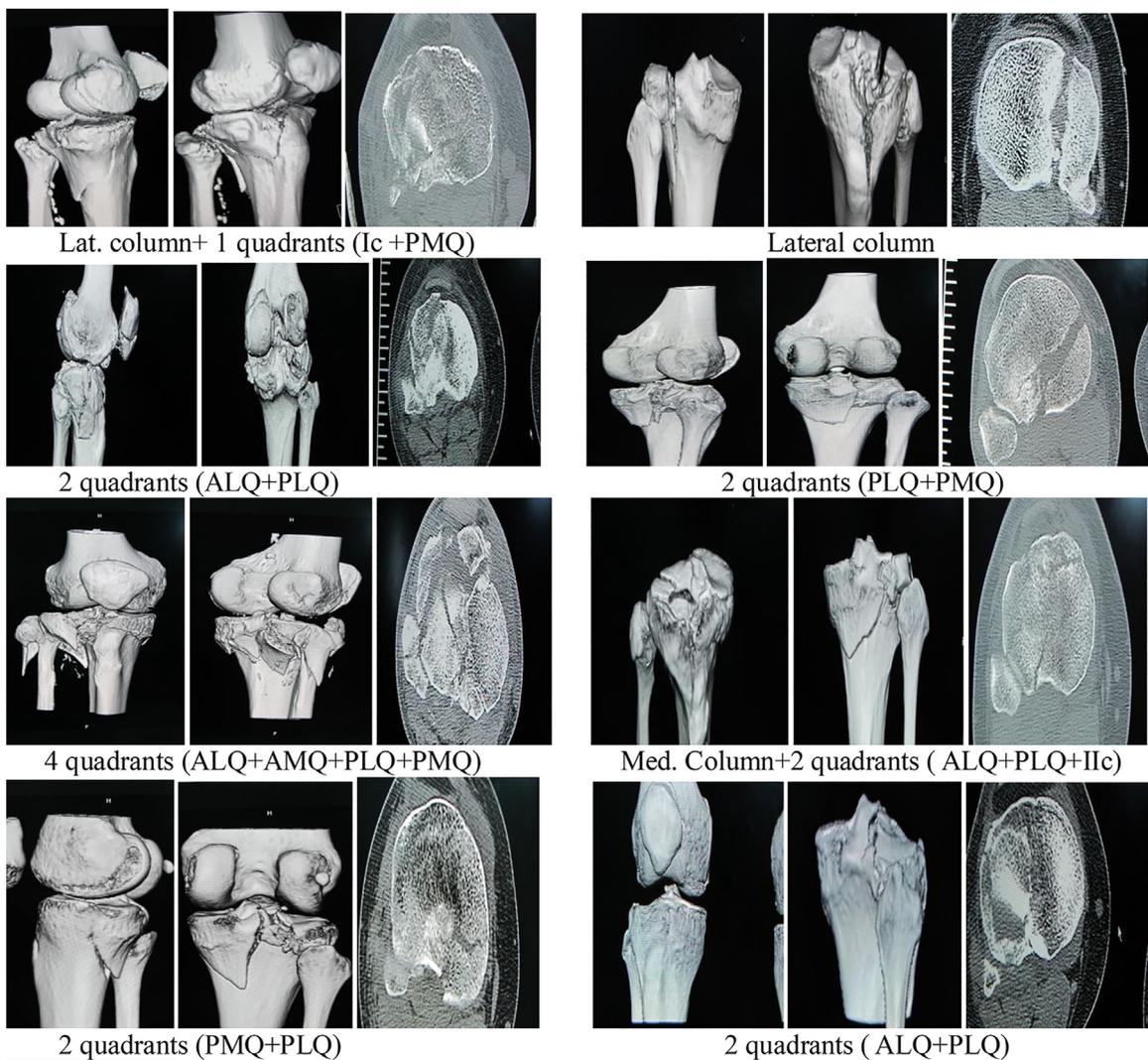
Fig. 2. (Continued)

anterior border of fibular head and point D is at anterior and posterior link of medial column. In this way we can get four parts named as quadrants. Anterolateral (ALQ) and posterolateral (PLQ) quadrants belongs to lateral column whereas anteromedial (AMQ

and posteromedial (PMQ) quadrants are in medial column as shown in Fig. 1. This anatomically based division guides the operative surgeon for direct anatomic reduction and fixation through relevant surgical approaches.

**Table 2**  
Comparison between Schatzker and Two column classification.

Quadrant specific Two Column Classification	Schatzker classification
Anterolateral quadrant split fracture = Ia1	I
Anterolateral quadrant isolated depression injury = Ia2	III
Anterolateral quadrant fracture and depression injury = Ia3	II
Posterolateral quadrant split fracture = Ib1	-
Posterolateral quadrant isolated depression injury = Ib2	-
Posterolateral quadrant fracture and depression injury = Ib3	-
Anteromedial quadrant split fracture = IIa1	IV
Anteromedial quadrant isolated depression injury = IIa2	IV
Anteromedial quadrant fracture and depression injury = IIa3	-
Posteromedial quadrant split fracture = II b1	-
Posteromedial quadrant isolated depression injury = IIb2	-
Posteromedial quadrant fracture and depression injury = IIb3	-
Both anterior quadrants = Ia IIa	V
Both posterior quadrants = Ib IIb	-
All the four quadrants = Ia IIa Ib IIb	-
Both column involvement and fracture line extends to diaphysis = III	VI



**Fig. 3.** Radiographic detail of various types according to proposed classification.

We prefer to classify the modalities separately. Our classification provides detail about fracture personality whether it is split, depression or comminuted depression split type. An alphanumeric system is used, which in some aspects is similar to that proposed by Muller et al. [1] the first letter of each type is used to describe

the relative column. We demonstrate the lateral column as type I injury and medial column as type II. The second letter represents the anatomic location. Anterior half denoted as “a” and posterior half as “b” while both and posterior halves together without and separation is represented by “c” demonstrating complete column



Fig. 3. (Continued)

**Table 3**  
Detail of classification by four observers.

System	Schatzker's Classification													
Types	I	II		III	IV	V			VI	Unclassified				
Numbers	1	16		2	6	10			6	3				
System	<b>Two Column Classification</b>													
Types	Ic	Iic	Ic+Iic	ALQ	PLQ	PMQ	2Qd	3Qd	4Qd	ALQ+Iic	PMQ+Ic	PMQ+Iic	PLQ+PMQ	III
Numbers	4	2	8	3	1	2	9	1	3	1	1	3	2	4

**Table 4**  
K value of Interobserver reliability between Schatzker and Two column classification.

Observers	Schatzker's classification	Two column classification
I-II	0.723	0.974
I-III	0.758	0.974
I-IV	0.823	0.922
II-III	0.683	0.948
II-IV	0.674	0.922
III-IV	0.711	0.897
Mean	0.723	0.939

lesion. The third number is used for fracture description. According to the severity of trauma the fractures are divided into three distinct subgroups. Simple split fracture is numerically labeled as 1, isolated depression injury as 2 and fracture depression injury as 3. Nomenclature of classification is given in Table 1 and Fig. 2. There may be any combination of above mentioned types. Bicondylar fractures of Schatzker's type VI with metaphysis and diaphysis dissociation are represented as type III injury in this newly described classification scheme. Two column classification can be used as a substitute to currently used classification systems as shown in the following Table 2.

*Clinical application and radiological demonstration*

Our classification is clinically valid. All 44 cases were categorized according to proposed classification. Axial transverse and three dimensional CT scans demonstration of different fracture types according to our classification is given in Fig. 3.

*Procedure of assessment*

Four observers including three orthopaedic traumatologists (one attending surgeon, and two senior residents) and a radiologist specializing in musculoskeletal system were selected. They were briefed about the four quadrants specific two column classification and Schatzker's classification. All of them were provided by written and diagrammatic description of the both classifications. Digital form of plain X-rays and CT images were evaluated by them separately and independently. The observers categorized the cases according to the Schatzker's and two column classification. The cases were arranged randomly. All the observers classified the radiographic images on two different instants 10 weeks apart. The chosen types of both classifications at the first analysis were not shown during the second analysis. Results categorized by observers are shown in Table 2.

*Statistical analysis*

K statistic [kappa] was used to evaluate reliability of Schatzker's classification and the proposed classification made by the same observer at different occasions (intra-observer reliability) and by

different observers at the same occasion (inter-observer reliability). Landis and Koch guidelines were used to categorize reliability levels of kappa values. K values ranging from +1 represents complete agreement, 0 representing no agreement, -1 representing complete disagreement, were assigned to results based on degree of agreement: slight agreement (0.01–0.20), fair agreement (0.21–0.40), moderate agreement (0.41–0.60), substantial agreement (0.61–0.80), and almost perfect agreement (>0.81). All statistical analysis was performed with SPSS Statistics 13 (SPSS Inc, Chicago IL).

**Results**

All cases were classified according to Schatzker's and two column classification. The categorized results are shown in Table 3.

*Inter-observer agreement*

The mean kappa value for inter-observer reliability using the Schatzker's classification systems was 0.723 (range, 0.674–0.823), representing "substantial agreement," on the other hand the mean kappa value was 0.939 (range: 0.897–0.974), representing "almost perfect agreement" according to two column classification. Results are figured out in Table 4, (See Fig. 4).

*Intra-observer agreement*

The mean kappa value for intra-observer agreement using the Schatzker's and two column classification systems were 0.789

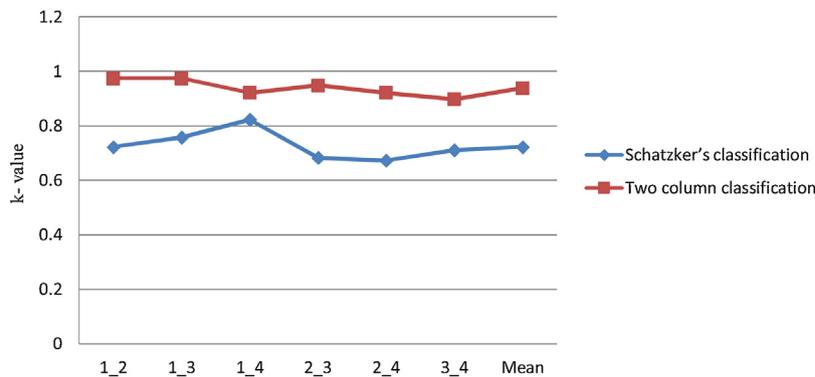


Fig. 4. K value of Interobserver reliability between Schatzker and Two column classification.

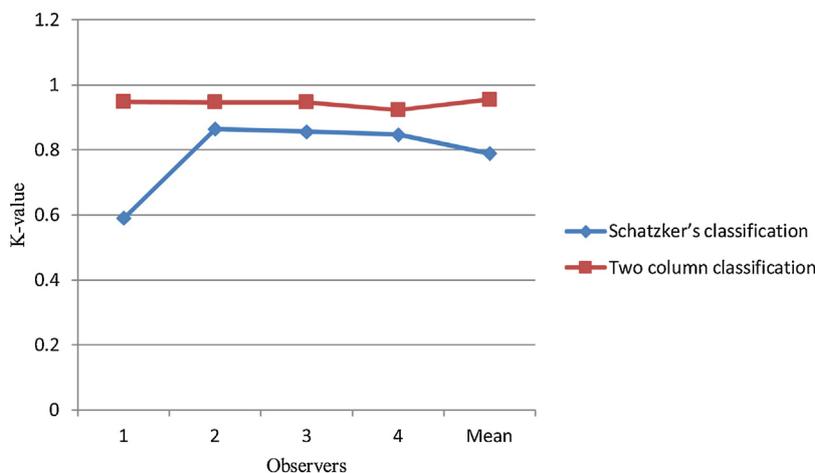


Fig. 5. K value of Intraobserver reliability for Schatzker and Two column classification.

**Table 5**  
K value of Intraobserver reliability for Schatzker and Two column classification.

Observers	Schatzker's classification	Two column classification
I	0.590	0.948
II	0.864	0.947
III	0.856	0.947
IV	0.847	0.923
Mean	0.789	0.955

(range: 0.590–0.864) and 0.955 (range: 0.923–0.948) showing “substantial agreement” and “almost perfect agreement” respectively. See Table 5 and Fig. 5.

## Discussion

A detailed understanding of complex intra articular nature of tibial plateau fractures is critical for preoperative planning to ensure optimal fracture fixation and promising post operative results. This would be possible if there is a concise classification system exists. Most of the current classifications of tibial plateau fractures use two dimensional X-rays. These systems are unable to provide proper detail about posterior aspect of tibia such as coronal plane fractures. These fractures should be identified by preoperative imaging modalities precisely otherwise the misunderstanding of these fractures may lead to inappropriate surgical approach or fixation strategies. In fact, use of CT has opened a new chapter in tibial plateau fracture classification. Application of CT scan for the evaluation of these fractures is well known [6,14,16,17,25]. Chan et al. [26] showed that addition of CT scan increases the agreement for surgical plan from 58% to 71% and surgeons changed treatment plan in over one quarter of cases. CT scanning also improves the inter- and intra-observer reliability and agreements of different classifications [27,28]. Reduction and fixation by indirect techniques via medial or lateral approaches are suboptimal for posterior quadrant injuries. Schatzker type I, II, and III fractures result from low energy trauma are lateral column injury (anterolateral quadrant) are treated through anterolateral approach. However, if the fractures are of complex nature such as concurrent posterolateral comminution and bulk of the posterolateral quadrant is compromised, a separate posterolateral approach is demanded [20, 29]. Schatzker type IV are medial column fractures usually reduced with medial plate via medial approach, but for fractures of posteromedial quadrant which was common finding in our case series a posterior inverted L shaped or posteromedial incision is mandatory for posterior buttress which is biomechanically more vigorous construct [30–32]. Schatzker types V and VI are high energy, complex bicondylar fractures. For bicondylar coronal plane fractures, we advocate the use of posterior inverted L shaped incision due to complications encountering with two separate posterior incisions [33]. The purpose of all these maneuvers is to achieve anatomic reduction and fixation. Recently three column classification advocated by Luo et al. [6] seems to be attractive but have some drawbacks in it. It is incomplete in its description as it is not based on type of fracture (depression injuries are neglected). Actually their classification concept was to advocate posterior buttress. There are some potential pitfalls while using three column classification. One of them is that in this classification they classify depression type injury as zero column injury but this type of injury should be addressed separately as it needs enblock elevation, bone grafting and fixation. Secondly, the severity of trauma in term of fractures and depressions or combined patterns is not evident, so it neglects the morphology of injury. Thirdly it has limitation in research work in sense of considering posterior aspect as one column but in fact posterior quadrants of both

medial and lateral columns are two different entities with totally different mechanisms of injury, incidences; posteromedial quadrant (59%) and posterolateral quadrant (7%) and prognosis [19,29]. Finally, this classification does not categorize tibial plateau fractures extensively and leaving several fracture types still remain unclassified. It also ignores prognosis in terms of fracture type. Every classification has its own purpose. The simpler classifications have high tendency to group different types of fractures in one category challenging reproducibility. However, more extensive schemes classify these fractures on the basis of different parameters, and the resultant classification pattern is comprehensive but difficult to remember and hard to apply in clinical practice. Review of the literature shows that most of the authors agree that it is imperative to consider the anatomic differences between the lateral and medial tibial plateaus when treating these injuries and should classify the fractures according to topographic differences. In this article, we formulate a new comprehensive anatomically based two column classification which is more informative. Profoundly confusing issues in three column classification are addressed. Pure split fracture, depression or their combinations are distinguished and numbered according to severity of trauma. We devised a quadrant specific column fixation concept; which is based on our new classification. Recently, several investigators revealed good inter-observer and intra-observer agreement while using CT [27,28,34,35]. In this study, we concluded that new classification was more reproducible than the Schatzker's classification.

## Conclusion

Our classification is a new twist in the understanding of tibial plateau fracture. We prefer to evaluate axial transverse, sagittal and coronal CT images together with 3D reconstruction images instead of totally rely on 3D CT due to artifact misconception in reconstruction images. Our classification depicts excellent detail of tibial plateau fracture and focus on quadrant specific fracture fixation that is directly related to our classification. By achieving quadrant specific two column fixation, the congruity of knee is restored. All other classification systems just describe fracture, mechanism of injury or provide information for surgical interventions. But all of them ignore and do not participate in research work. To our best knowledge this classification can be a reliable research vector than any other classification of tibial plateau fractures. Sub types in the scheme can be used to individualize the specific fracture category, relative incidence, focused treatment and prognosis. It shows high inter- and intra-observer agreement and it can be used as a supplement to the conventionally used Schatzker's classification or even substitute to it. Authors suggest a large multi-center study.

## Conflict of interest

There is no conflict of interest. No grants, funds or benefits were obtained concerning this study.

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