International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Role of Multi Detector Computed Tomography with 3D Reformation versus Plain Radiography in the Evaluation and Classification of Posterior Column Involvement in Tibial Plateau Fractures

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Abstract: ***Objective: The purpose of our study is to determine the role of3 - Dimensional Computed Tomography in the evaluation of posterior column involvement intibial plateau fractures of the knee for preoperative evaluation and surgical planning by using Three - column and Schatzker's classification systems. Materials and Methods: Fifty patients of knee trauma underwent Plain Radiography and CT with 3 - Dimensional reconstruction. The characterization and type of fractures were evaluated in all the cases. Results: In our study, 50 tibial plateau fractures were examined with plain films and MDCT with 3D reformation. The posterior column involvement was underestimated in 11 cases in Plain Radiography while MDCT accurately detected the fracture pattern in all the cases. Schatzker's classification system had the drawback of not including posterior column involvement. Conclusion: MDCT with 3D reformation proved to be superior to Plain Radiography in complete depiction of the fracture pattern, which led to preoperative modifications that prevented dreadful post - operative complications. The three - column classification seemed to be an effective way to characterise and classify fractures of the tibial plateau.***

Keywords: Tibial plateau, Three - column classification, Schatzker's classification, Plain Radiography, Multidetector Computed Tomography

1. Introduction

The knee joint is complex and most commonly injured joint now - a - days because of increased motor vehicle accidents, fall or sports related injuries[1]. Thetibial plateau is a flat surface formed by medial and lateral condyles of the tibia, which articulates with the femoral condyles to form the major articulation of the knee. Tibial plateau fractures are complex fractures of the knee and are common following a high energy or low energy mechanism. Most fractures involve articular depression leading to joint incongruity. Treatment of these fractures may be complicated by knee stiffness, loss of range of movement, strength and function in the lower limb. Optimal reconstruction should restore the mechanical axis, provide a stable construct for mobilization and re - establish articular congruity.

Initial evaluation includes Plain Radiography of the knee joint. However, it is almost impossible to identify and evaluate fractures with posterior column involvement by X - Rays alone due to overlap between the fracture and normal bone. Because of this difficulty, the next step study in the evaluation of knee trauma is MDCT. The effective dose for the knee is 1mSv, which is considered as a low dose examination. In addition, MDCT permits imaging through splints and casts without decrease in image quality, and processing of the knee is not as critical as for radiography.

There are numerous classification systems used for tibial plateau fractures to help classify the fractures and facilitate the treatment plan. Schatzker, Hohl and Moore and Arbeitsgemeinschaft fur Osteosynthesefragen (AO) are the commonly used classification systems. The Schatzker system is the frequently used among these. The three - column classification described by Luo et al.3 has been the new addition to the previous classification systems.

Aim:
To assess the role of MDCT and plain radiography in the evaluation of posterior column involvement intibial plateau fractures and deciding on the appropriate treatment.

Objectives:

- To determine the value of MDCT and plain radiography in the evaluation of posterior column involvement intibial plateau fractures.
- To determine the value of MDCT in classification of tibial plateau fractures using combination of both Schatzker's and Three - column fracture classification systems.

2. Materials and Methods

Source of data:

Fractures in and around the knee joint referred to Department of Radiodiagnosis, Assam Medical College, Dibrugarh were evaluated during the period of December 2021 to November 2022. Patients with old tibial plateau fractures were excluded from the study. Ethical approval was obtained from the Committee of the Medical Ethics of the hospital. All patients provided their written informed consent in their study.

Mechanism of injury:

Injuries to the plateaus occur as a result of force either directed medially or laterally.

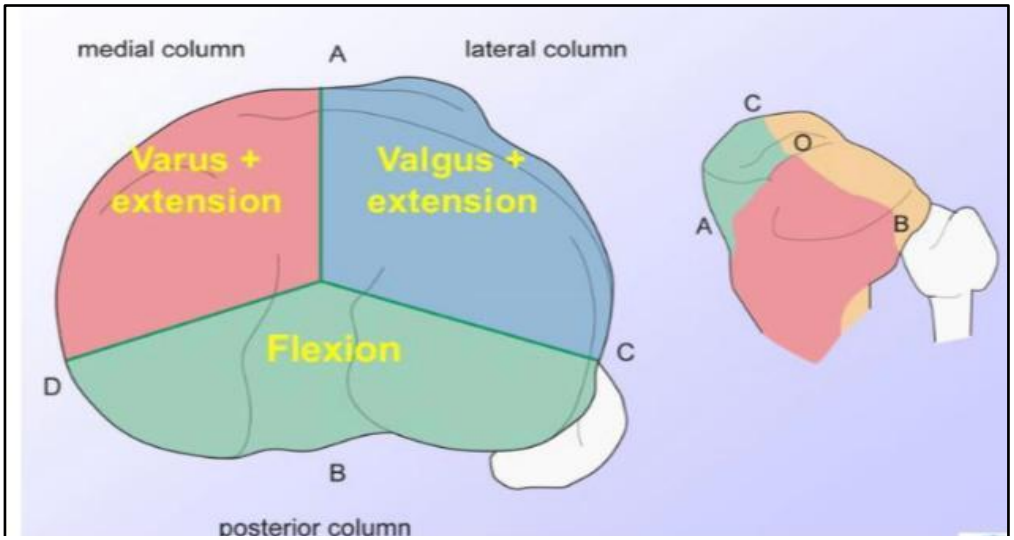


Figure 1: Morphology and injury mechanism

Radiology protocol:

Radiography was performed with a computed radiography unit ALLENGERS - 525 X - Ray machine. Radiography was done in the standard AP and lateral views with 59 KVP and 18 mAS.

MDCT of the knee was performed in all cases using PHILIPS BRILLIANCE iCT 256 CT SCAN. Scans were acquired in the helical mode to reduce motion artifacts. Scanning parameters of 120 Kv, 240 mAs, 2 mm section thickness 0.5 mm collimation were taken. With the patient in supine position, axial images were obtained from upper pole of the patella upto the caudal end of the fibula using bone algorithm. Acquired data were post processed, multiplanar reformations and volume rendered 3D reconstructions were obtained. Independent assessment of axial, coronal and sagittal reformatted and volume rendered images were performed. The region of interest was assessed for the involvement of posterior column. Specific scores were given for each finding in both plain radiography and MDCT. On the basis of posterior column involvement the fractures were classified into 5 grades (0 to 4) in both Plain radiography and MDCT.

Table 1: Grading of assessment of involvement of posterior column

Grading	Involvement of posterior column
0	Cannot be commented
1	Not detected
2	Not detected inspite of being involved
3	Well detected
4	Extremely well detected

Measuring procedures and classification system:

Both the Schatzker[2] and Three column classification systems were used for classification of tibial plateau fractures.

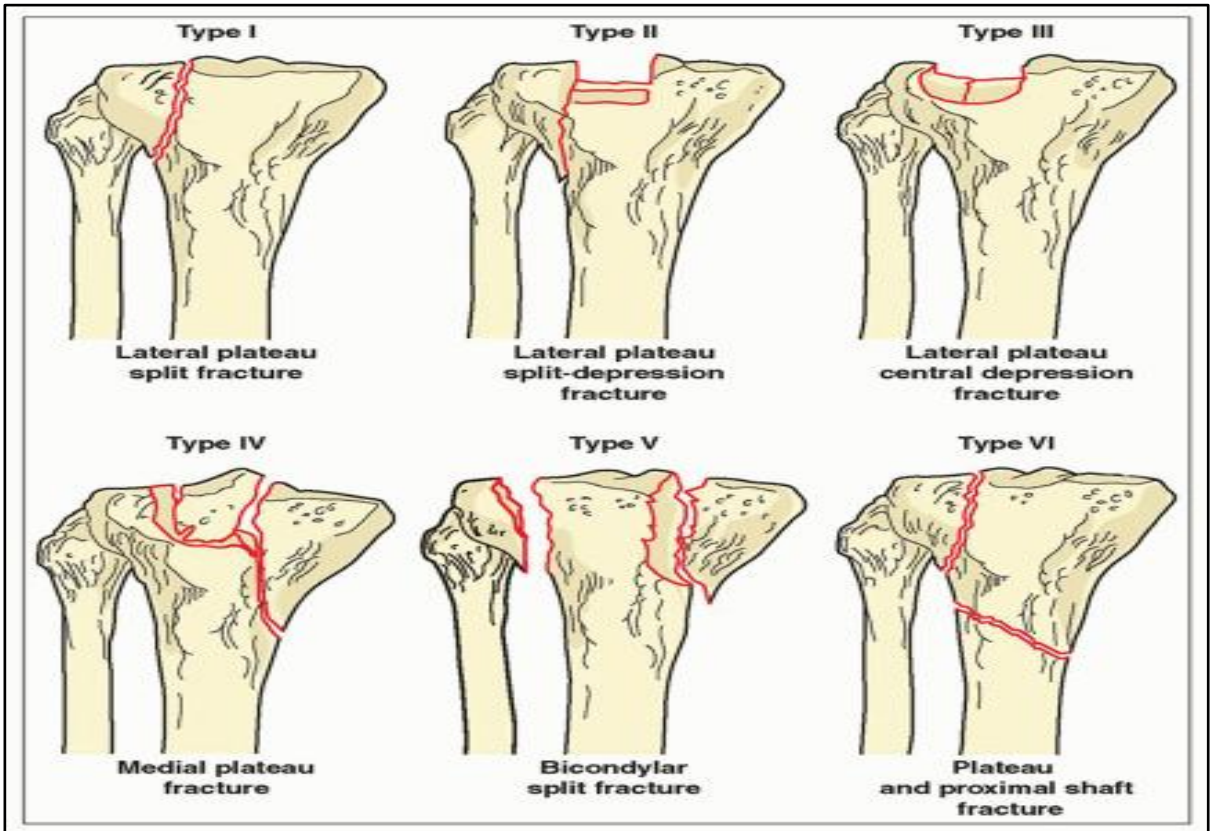


Figure 2: Schatzker's classification of tibial plateau fracture

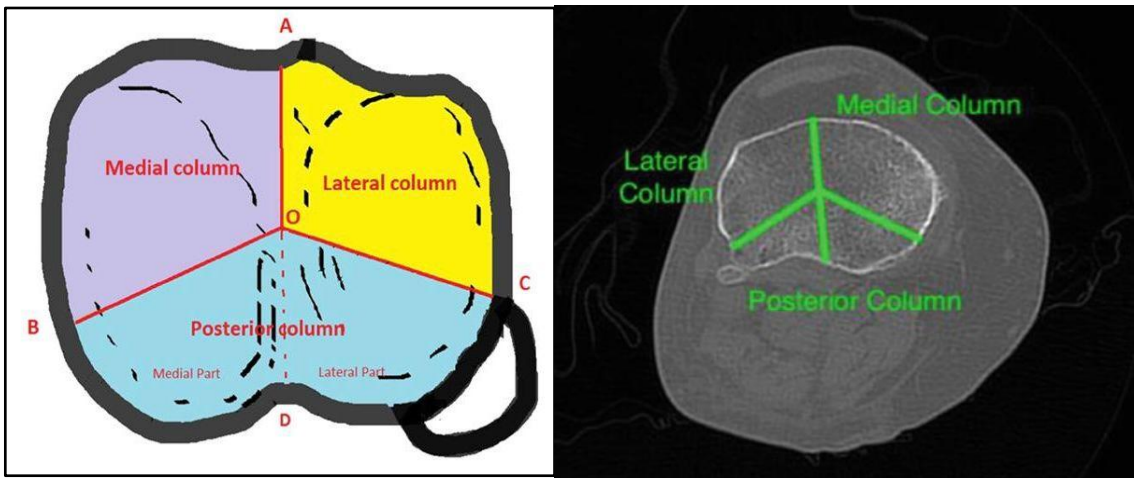


Figure 3: The three column concept according to Luo et al (Point O represents the artificial axis of the 3 columns and is defined as midpoint between the two tibial spines; A is found on the anterior tibial tuberosity and, when connected to point O, it divides the lateral and medial column; point B represents posteromedial ridge of the tibial plateau; point C represents the most anterior border of the fibular head, when connected to point O, divides the posterior and lateral column)

According to the Three - column classification, one independent articular depression with a break of the column wall is defined as a fracture of the relevant column. As described in Fig 3, a pure depression in any three columns was classed as zero column, pure split and split with depressions were classified according to the column involved as per the CT scans.

Statistical analysis:

The data collected was tabulated in Microsoft Excel Worksheet and computer based analysis was performed using the Statistical product and service solutions (SPSS) 20.0 software (SPSS, Chicago, Illinois, USA) and Microsoft Excel 2010. The categorical variables were summarized as percentages. The study is a hospital based observational study, so no statistical analyses between the parameters were evaluated.

3. Observations and Results

Study design: A hospital based observational study and evaluation of study group consisting of 50 patients with knee trauma is undertaken to study the spectrum of Plain Radiography and MDCT findings.

1) Age Distribution

Table 2: Distribution of age among study participants

Age Group (in years)	Number of Patients	Percentage
<20	3	6
20–30	10	20
31–40	15	30
41–50	11	22
51–60	8	16
>60	3	6
Total	**50**	**100**

In this study, most patients with tibial plateau fractures belonged to the age group of 31 - 40comprising of 30.00% (15 patients).

2) Gender Distribution

Table 3: Gender wise distribution among study participants

Gender	Number of Patients	Percentage
Male	36	72
Female	14	28
TOTAL	**50**	**100**
Ratio (Male: Female)	2.5: 1	

The study population consisted of 36 males and 14females.

3) Mode of injury

Table 4: Mode of injury among study participants

Mode of Injury	Number of Patients	Percentage
RTA	46	92
Fall	4	8
TOTAL	**50**	**100**

Road traffic accident was found to be the most common cause for tibial plateau fractures in this study comprising of 92.00% (46 patients).

4) Posterior column involvement

Table 5: Plain radiography findings for assessment of involvement of posterior column among study participants

Involvement of Posterior Column	Cannot be Commented	Not detected	Not Detected inspite of being involved	Well Detected	Extremely Well Detected
Antero - posterior	21 (42.00%)	16 (32.00%)	11 (22.00%)	2 (4.00%)	0 (0.00%)
Lateral	18 (36.00%)	19 (38.00%)	13 (26.00%)	0 (0.00%)	0 (0.00%)

Table 6: Computed Tomography findings for assessment of involvement of posterior column among study participants

Involvement of posterior column	Cannot be Commented	Not Detected	Not Detected inspite of being involved	Well Detected	Extremely Well Detected
Axial	8 (16.00%)	29 (58.00%)	11 (22.00%)	2 (4.00%)	0 (0.00%)
Sagittal	2 (4.00%)	35 (70.00%)	1 (2.00%)	6 (12.00%)	6 (12.00%)
Coronal	0 (0.00%)	37 (74.00%)	0 (0.00%)	3 (6.00%)	10 (20.00%)
3DCT	0 (0.00%)	37 (74.00%)	0 (0.00%)	2 (4.00%)	11 (22.00%)

Anterior posterior view detected posterior column involvement in 2 cases on Plain Radiography, while lateral view detected none. Thus, posterior column involvement in tibial plateau fractures were obscured by both the views in majority of the cases. Sagittal, coronal reformatted and 3D CT images were equally efficient in assessment of posterior column involvement to some extent. Axial imaging detected only 2 out of 13 cases of posterior column involvement.

5) Classification of fracture

Table 7: Assessment of type of tibial plateau fractures among study participants based on Schatzker's classification on Plain Radiography

Schatzker's Classification	Description	Number of Patients	Percentage
Type I	Pure cleavage of lateral tibial plateau	1	2
Type II	Splitting and depression of lateral tibial plateau	2	4
Type IIIa	Pure depression of lateral plasteau with lateral tibial depression	0	0
Type IIIb	Pure depression of lateral tibialplasteau with central depression	0	0
Type IV	Split or depression of medial tibial plateau	1	2
Type V	Wedge fracture of both lateral and medial tibial plateau	9	18
Type VI	Transverse tibialmetadiaphyseal fracture along with any of the tibial plateau fracture	25	48

Out of 50 cases with tibial plateau fractures, 38 cases were categorized into different types of Schatzker'sClassification, majority (25 cases) belonged to type VI. Fractures were obscured in 12 cases in anterior - posterior view

Table 8: Assessment of type of tibial plateau fractures among study participants based on Three column and Schatzker's classification. [31]

Three - Column Classification	Schatzker's Classification	Description	Number of Patients	Percentage
One column	Type I	Pure cleavage fracture of lateral tibial plateau	3	6
One column	Type II	Cleavage combined with depression of lateral tibial plateau	8	16

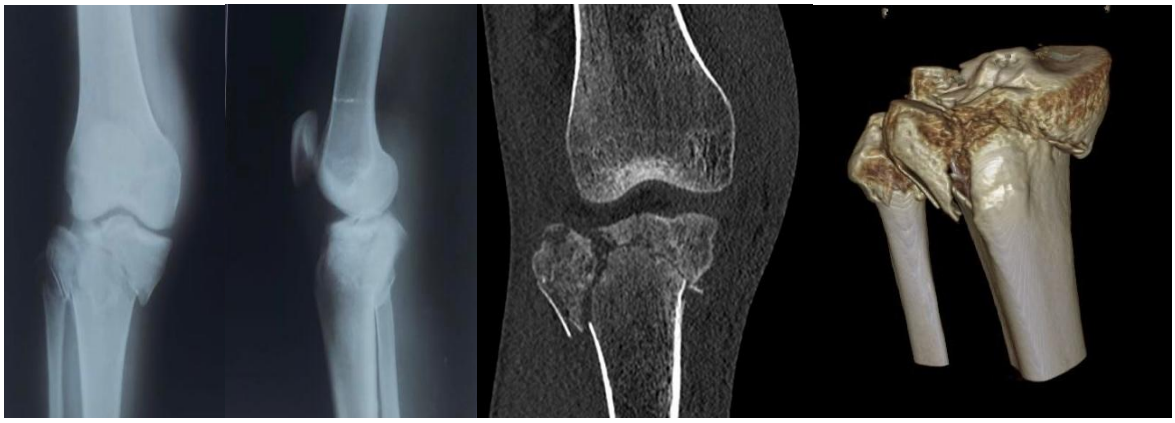
One column - posterior	Not included	Posterior column fragment, without involvement of anteromedial or anterolateral columns	1	2
Zero column	Type IIIA	Pure lateral depression of lateral tibial plateau	0	0
Zero column	Type IIIB	Pure central depression of lateral tibial plateau	0	0
Two column	Type IV	Medial tibial plateau fracture with a separate split or depressed component	1	2
Two column	NA	Lateral tibial plateau fracture with a separate split or depressed component	2	4
Three column	Type V	Wedge fracture of lateral and medial tibial plateau	10	20
Three column	Type VI	Variable bicondylar fracture pattern with transverse subcondylar fracture and dissociation of metaphysis from diaphysis	13	26
Three column (posterior column component)	NA	Separate fragments in each of the three columns	12	24
TOTAL			**50**	**100**

Majority of the fractures (13) belonged to Three column Type VI fractures.12 cases were classified as Three column posterior (Schatzker type NA), 10 cases as three column type IV, 8 cases as one column type II, 3 cases as one column type I, 2 cases as two column (Schatzker type NA) and 1 case each as one column posterior (Schatzker type NA) and two column (Schatzker type IV) respectively.

4. Mode of Treatment

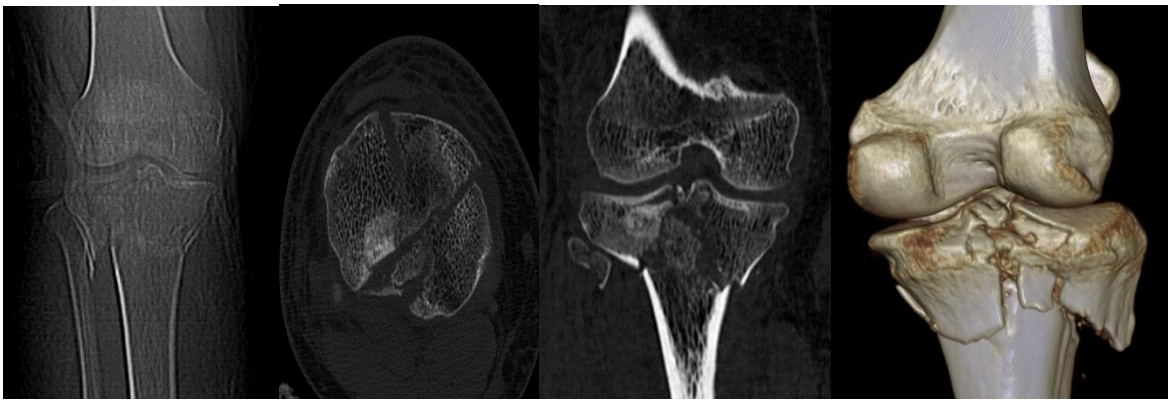
Majority of the patients (47) with tibial plateau fractures underwent surgical treatment. Only three patients were treated conservatively.

Case 1: Posterior column (one column) fracturein a female patient aged 22 years with history of RTA. Both AP and lateral views of plain radiography did not identify any fracture. Sagittal reformatted and VR images show comminuted displaced fracture of posterior column which was obscured in both views of plain radiography.



Case 2: Three column fracture (Schatzker type NA) in a male patient aged 53 years with history of RTA AP and Lateral Plain Radiography showing displaced fracture of both the medial and lateral tibial condyles. Coronal reformatted and VR images show separate fragments in each of the three columns, viz. medial, lateral and posterior columns. Comminution and posterior column involvement was not identified on Plain Radiographs.

Case 3: Two column fracture (Schatzker type IV) ina32 years aged male with history of RTA Plain. Radiography showing depressed fracture of medial condyle with involvement of intercondylar area. Axial. Coronal and VR images showing split and depressed fracture of medial tibial condyle along with extension of fracture line to involve intercondylar area.



Case 4: Three column fracture (Schatzker type VI) in a 40 years aged female with history of RTA. Plain Radiography, Axial, Coronal reformatted and VR images show variable bicondylar fracture pattern with dissociation of the metaphysis from diaphysis along with involvement of posterior column.

5. Discussion

Mean age of participants was 39.50 years with 13.36 SD. Highest number of patients belonged to age group of 31 - 40 years. Around 72.00 % participants were males and 28.00 % were females. The most common mode of injury was due to road traffic accident (92.00 %) followed by injury due to fall (8.00 %).

On interpretation of the antero - posterior and lateral images for the dectection of posterior column involvement, it was found that antero - posterior view identified the posterior column fracture in 2 cases (4.00%) while lateral view detected none.

Sagittal, coronal reformatted and 3D CT images were equally efficient in assessment of posterior column involvement. Axial imaging was not that efficient in assessment of posterior column involvement, as it detected only 2 out of 13 cases (4.00 %).

Out of 50 cases of tibial plateau fractures, 38 cases were categorized into different types of Scatzker's classification. There were 12 patients in whom fractures were obscured on anterior posterior view in plain radiography.1 case was diagnosed as Schatzker type I, 2 cases were diagnosed as Schatzker type II, 1 case was diagnosed as Schatzker type IV, 9 cases were diagnosed as Schatzker type V and 25 cases were diagnosed as Schatzker type VI based on Plain Radiography alone.2 out of 9 cases classified as Schatzker type V in Plain Radiography were modified to Three column Schatzker type VI in pre - operative MDCT. Out of 12 cases obscured in Plain Radiography, 2 cases were diagnosed as One column Schatzker type I, 6 cases were diagnosed as One column Schatzker type II, 1 case was diagnosed as One column posterior (Schatzker type NA), 2 cases were diagnosed as Two column (Schatzker type NA) and 1 case was diagnosed as Three column Posterior (Schatzker type NA) in pre - operative MDCT. Out of 25 cases diagnosed as Schatzker type VI on Plain Radiography alone, pre - operative MDCT additionally detected 12 cases of posterior column involvement which were obscured on Plain Radiography.

In pre - operative MDCT, majority of the cases (26.00 %) belonged to Three column Type SchatzkerVI fractures.24.00 % of cases were classified as Three column posterior (Schatzker type NA), 20.00 % of cases as Three column Schatzkertype IV, 16.00 % of cases as One columnSchatzker type II, 6.00 % of cases as One column Schatzkertype I, 4.00% of cases as Two column (Schatzker type NA) and 2.00 % of cases each as One column posterior (Schatzker type NA) and Two column (Schatzker type IV) respectively.

Patange S. P. et al[4] in their study characterised the fracture pattern according to the areas involved, i. e. medial, lateral and posterior columns. There were a total of 31 % (17 patients) with the posterior column involvement. The inter -

observer values were excellent for both imaging modalities indicating that the surgeons agreed amongst themselves and were able to reproduce similar results on separate occasions in quantifying the involvement of posterior column fractures. In our study, we found that there were 13 patients with posterior column involvement nearly 26.00 % of the total population group.

Limitations of our study

1) MDCT with 3D volume rendering can only detect osseous pathology and cannot evaluate meniscal and ligament injuries.
2) Since ionizing radiation is involved, MDCT cannot be used in pregnant females.
3) Motion artifact will render unsatisfactory 3D imaging.

6. Conclusion

1) Traditional descriptions of tibial plateau fractures are well established but limited by reliance on AP/Lateral Radiography due to overlap between the fracture and normal bone and inadequate depiction of posterior column involvement.
2) Schatzker's classification system had the drawback of not including the posterior tibial plateau fractures, conforming to the morphology of 13 cases in our study.
3) Posterior column fracture demands surgical fixation and if not considered, it may lead to varus collapse in the post - operative period and reduced range of movements of the knee.
4) In our study, pre - operative MDCT led to modifications in the classification of tibial plateau fractures and the surgical plans were devised as per the particular type encountered which prevented dreadful post - operative complications.

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