Reliability of Radiographic Assessment of Tibial Plateau Fracture

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Key words:
Tibial plateau, fracture radiographic, reliability of x rays, validity of tibial x rays, fractures functional outcome

Abstract:

Introduction:

Tibial plateau is a common fracture that represents 1% of all adult fracture. Schatzker's type II is the most common type among tibial plateau fractures. There is a significant heterogeneity in use and reporting of radiographic measures. This is related to the Difference of injury patterns, to the difference of radiographic measures and to non-standardized measurement techniques. To obtain a functional outcome result of surgical reduction and fixation, a valid set of radiographic assessment is critical. Up to our knowledge, there have been no standardized parameters to assess tibial plateau fractures.

Objective: to define a set of radiographic measures for Schatzker's II Tibial Plateau fractures and to test the inter-observer reliability of these measures.

Methodology: 47 patients with split depression tibial plateau fractures were included in study. Standardized prints of preoperative and postoperative x-rays were available for examination by 4 orthopedic trauma surgeons. 6 radiographic parameters as well as a severity score system were introduced. These includes coronal plane maximum depression (CPMD), coronal plane lateral joint line angle (CPLJA), coronal plane widening (CPW), sagittal plane maximum depression (SPMD), sagittal plane lateral joint angle (SPLJA) and sagittal plane medial joint angle (SPMJA). Instruction sheets of how to obtain theses parameters were provided. Interclass correlation factor (ICC) and Kappa factor were used to assess the inter-observer correlation.

Results: ICC for CPMD readings of pre-operative films was 0.636 with 95% confidence interval (CI) set around 0.5-0.76. Postoperative reading has ICC of 0.301 with 95% CI set between 0.15-0.47. ICC of CPLJA was 0.701 in pre-operative x-rays and was 0.337 in postoperative x-rays (95% interval :0, 58-0.81; 0.17-0.51 respectively). Assessment CPW in preoperative and postoperative films yielded ICC of 0.77 and 0.38 respectively (95% CI: 0.66-0.85, 0.34-0.52 respectively).

Assessment of SPMD had an ICC of 0.68 and 0.39 of preoperative and postoperative images (95% interval: 0.54-0.8; 0.2-0.5 respectively). ICC of SPMJA assessment was 0.41 and 0.39 for preoperative and postoperative x-rays respectively (95% CI: 0.26-0.58; 0.26-0.54 respectively). ICC of SPLJA was 0.54 and 0.41 for preoperative and postoperative images respectively (95% CI: 0.39-0.69; 0.28-0,56). Overall Kappa value of Severity scale classification was 0.22.

Conclusions: Good correlation can be found during assessment of coronal parameters of preoperative x-rays. Only fair correlation can be found during assessment of most of parameters of postoperative x-rays. Assessment of preoperative x-rays can be used more reliable in prognostic studies. A study to validate the use of CT scan to assess postoperative reduction could be useful prior to conducting functional outcome studies of surgical fixation of tibial plateau fractures.

Introduction:

Tibial plateau fractures are common injuries, comprising 1% of all fractures in adults and up to 8% of fractures in the elderly. The most common mechanisms of injury include motor vehicle accident (51%), fall from a height (40%) and sport injuries (4%) (8). Type II of Schatzker's classification is the most common pattern of tibial plateau fractures. Being intra-articular fractures of a major weight-bearing joint, it would be logical to assume that congruent articular reduction and restoration of lower extremity alignment are key factors in determining the clinical outcomes from these injuries. However, there is still a debate regarding the most influential factors affecting these outcomes.

Several cadaveric studies were conducted to quantify the contact pressure on incongruent knee joint. A step off deformity of lateral tibial plateau of 1.5 and 3 mm resulted in 50 % and 75% increase of contact pressure respectively (4). The extent of this step off deformity also had a significant correlation with the valgus angulation of the knee axis. At six mm step off, the valgus angulation increased an average 7.6 degrees (1). A five degrees increase of the knee valgus axis will result in a double peak pressure on the lateral plateau (11).

The term of "accepted reduction" of tibial plateau fractures is yet to be defined. Some authors believed that inter-articular displacement is irrelevant to the final clinical outcome (2,6,15). Others showed that reduction of these displacements has positive influence on the clinical and/or functional outcomes. However, values of displacement less than 2 mm to 10 mm were shown to be correlated with accept outcomes (1.3.4.5.9.16). Furthermore, some authors signified other elements of reduction like axial alignment (9,15,16) and coronal widening (9,15) as a determinant of clinical outcomes. Factors including age at presentation (17,18,19), patient weight (19) and fracture type (13,16) also have been shown to play role in the final outcomes.

Reliability of radiographic analysis of tibial plateau fractures (different types) was studied by Martin et al. The quantitive measures (joint depression and widening) did approach acceptable inter-rater agreement but with extremely wide tolerance limits (12mm and 9 mm respectively). Consequently, they concluded that reliability of fracture classification is limited by raters' abilities to agree on basic radiographic assessments (14).

In order to correlate any functional outcome instrument to the radiographic findings, it is essential to have valid radiographic parameters to start with. The goal of this study is to select a single fracture type, to introduce a radiographic parameters and to test their inter and intra-observer reliability and reproducibility.

Methodology:

We reviewed data collected on all patients with tibial plateau fractures treated surgically in our institution since December 2004. All patients have consented to inclusion in our database under the guidance of our institutional ethics committee. We chose to examine only those with split-depression (Schatzker's II) lateral tibial plateau fractures in this study because these are the most frequent type of tibial plateau fracture and to simplify the process of standardizing the radiographic assessment.

Our inclusion criteria included split depression lateral tibial plateau fracture, available relevant patient's data and accessibility to compete set of pre-operative radiographs (AP/lateral X-ray and CT scan). Of 67 patients were identified with Schatzker's II tibial plateau fractures, 43 patients (fractures) were included in the study. Demographic data of patients are shown in table1.

Patients	
Female	19
Male	24
Mean age (years)	47 (24-76)
Mechanism of injury	
Fall	22
MVC/pedestrian	18
Direct blow	3

In order to standardize the radiographs from which measurements would be taken and eliminate any differences of scale, we elected to convert each radiograph into a photographic print, resizing as necessary to ensure that the narrowest part of the distal femur was constant. Patient details were removed during this process and each image was assigned a number to which the results could be tabulated. Four orthopedic trauma surgeons evaluated these prints on one occasion, so that the inter-observer reliability could be calculated.

The evaluation was conducted according to a given instruction sheets which described the six measurements to be recorded. These were available and accessible throughout the evaluation process. The instructions provided are given below:

<u>Coronal plane maximum depression (figure</u> 1/A)

1. Draw the anatomic axis of the tibia (red).
2. At the level of the lowest point of the medial tibial plateau, draw a line perpendicular to the anatomic axis (yellow).
3. Identify the lowest point of the lowest articular fragment (B).
4. Draw a line that passes at point B and parallel to the anatomic axis of tibia, black)
5. Mark the intersection between the yellow and black lines, (A).
6. Measure the distance A-B.

Coronal plane lateral joint line angle (figure 1/B)

1. Draw the anatomic axis of the tibia (red).
2. At the level of the lowest point of the medial tibial plateau, draw a line perpendicular to the anatomic axis (yellow).
3. The intersection of these two lines is point B.
4. Identify the lowest point of the lowest articular fragment(C).
5. Draw a third line (blue), which passes through both points B and D.
6. Measure the angle CBD.

Coronal plane widening (figure 1/C)

1. Draw the anatomic axis of the tibia (red).
2. Draw a line parallel to the anatomical axis of tibia and passes by the most lateral point of lateral femoral condyle (blue).
3. Identify the most lateral point of lateral tibia plateau (point C).
4. Draw a line parallel to the anatomical axis of tibia and passes by point C (yellow).
5. Draw a line that is perpendicular all the three lines and passes by point C.
6. Calculate BC/AB.

Figure 1: coronal X-rays assessment

A B C

Sagittal plane maximum depression (figure 2/A)

1. Draw the anatomic axis of the tibia parallel to posterior cortex of shaft (red).
2. Draw a line from the highest articular point anteriorly to the highest articular point posteriorly of the medial tibial plateau (blue).
3. Identify the lowest point of the lowest articular fragment of lateral plateau (B).
4. Draw a Line that passes by point B and parallel to the anatomic axis of tibia (yellow).
5. Mark the intersection between the yellow and blue lines as point A
6. Measure the distance AB.

Sagittal plane lateral & medial joint line angle (figure 2/A)

1. Draw the anatomic axis of the tibia (red).
2. Draw a line from the highest articular point anteriorly to the highest articular point posteriorly of the **medial** tibial plateau (blue).
3. The angle ABC represents the normal posterior tibial slope.
4. Draw a line from the highest articular point anteriorly to the highest articular point posteriorly of the **lateral** tibial plateau (yellow).
5. The angle ADE represents the lateral posterior slope (l)
6. Calculate the Difference between angles as following:
    - ABC - ADE = positive value: lateral plateau posterior slope
    - ABC - ADE = negative value: lateral plateau Anterior slope

Figure 2: sagital X-rays assessment

A B

We created a quality parameter scoring system to evaluate the comminution bases on number of pieces as shown in figure 3.

I	Single large depressed fragment
II	Mild comminution: 2 fragments visible on AP or Lateral
III	Severe comminution: 3 or more fragments visible on the AP or lateral

Figure 3

Interclass coefficient and Kappa coefficient were used to assess the inter-observer correlation within 95% confidence interval

Results:

Charts of 58 patients were reviewed. A 44 pre-operative x-rays and 58 post operative x-rays were included in the study. We had 32 males sand 26 females. Mean age of our patients was 47 years.

Intraclass correlation (ICC) for coronal maximum depression readings of pre-operative films was 0.636 with 95% confidence interval (CI) set around 0.5-0.76. Postoperative reading has ICC of 0.301 with 95% CI set between 0.15-0.47. ICC of coronal lateral joint angle was 0.701 in pre-operative x-rays and was 0.337 in postoperative x-rays (95% interval :0, 58-0.81; 0.17-0.51 respectively). Assessment of coronal widening in preoperative and postoperative films yielded ICC of 0.77 and 0.38 respectively (95% CI: 0.66-0.85, 0.34-0.52 respectively).

Assessment of sagittal maximum depression yielded an ICC of 0.68 and 0.39 of preoperative and postoperative images (95% interval: 0.54-0.8; 0.2-0.5 respectively). ICC of sagittal medial slope assessment was 0.41 and 0.39 for preoperative and postoperative x-rays respectively (95% CI: 0.26-0.58; 0.26-0.54 respectively). ICC of Sagittal lateral Slope was 0.54 and 0.41 for preoperative and postoperative images respectively (95% CI: 0.39-0.69; 0.28-0,56).

Overall Kappa value of Severity scale classification was 0.22. Type 1 and type 3 readings were more consistent than type 2 with a Kappa value of 0.33 (P value 0.0) and 0.35 (P value: 0.0) vs. 0.028(P value: 0.33).

Coronal Widening	0.768	Good
Coronal Lateral Joint Angle	0.701	Good
Sagittal Maximum Depression	0.680	Good
Coronal Max Depression	0.636	Good
Sagittal Lateral Slope	0.542	Moderate
Sagittal Medial Slope	0.412	Moderate

Table 1: preoperative

Sagittal Lateral Slope	0.412	Moderate
Sagittal Medial Slope	0.395	Fair
Sagittal Maximum Depression	0.391	Fair
Coronal Widening	0.375	Fair
Coronal Lateral Joint Angle	0.337	Fair
Coronal Max Depression	0.301	Fair

Table 2: postoperative

Discussion:

The summary of preoperative images assessment ICC values and interpretations is shown in table 1. There is more coherent reading between examiners of coronal pre-operative images. This is also found during assessment of maximum sagittal depression. Other sagittal parameters used in preoperative assessment can only be determined in moderated consistency. This may reflect the difficulty to standardize how to obtain a lateral x-rays in emergency settings. The maximum depression of sagittal films seemed less affected as it might be due to 2 points measurements rather than angels assessments. In other hand, Postoperative x-rays parameters assessment showed only fair correlation with one except (table 2). This one was the sagittal lateral slope parameter, which showed a moderate correlation. This can be explained by the difficulty of recognize small values resulted from surgical reduction and the obliteration effect of hardware. Severity score had the least reliability among other parameters.

This study shows that agreement on assessment of simple type fracture of tibial plateau can be difficult. It emphases the importance of including pre-operative x-rays assessment into any correlation with functional outcomes (prognostic) as they can be more reliably evaluated. However, this can be confounded by quality of surgical reduction and post surgical care. Among our parameters, coronal widening, coronal lateral joint angle and sagittal maximum depression are more reliable than other. A 3D image evaluation such as CT scan might be able to simplify evaluation of post-surgical reduction and to correlate that with functional outcomes.

Summary:

Postoperative standardized x-rays evaluation of tibial plateau fractures (Schatzker's II) can be only fairly reliable. This should be taken into account when correlation of X-rays measures with functional outcomes studies. The pre-operative X-rays evaluation is more reliable and can be used in prognostic studies, keeping in mind the confounding factors of quality of surgical care. Adding a 3D evaluation of fractures during functional assessment studies can be valuable.

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