World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Assessment of intra-articular tibial plateau fractures by the three-dimensional revised Schatzker classification: Study of 94 cases

Orestes Oluwafemi Zoffoun *, Aboubacar Lawan Abdou, Saber Zari, Hicham Yacoubi and Abdeljaouad Najib

Department of Orthopedic Trauma, University hospital center of Oujda, Morocco.

World Journal of Advanced Research and Reviews, 2022, 14(01), 270–276

Publication history: Received on 07 March 2022; revised on 10 April 2022; accepted on 12 April 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.14.1.0314

Abstract

Background: The functional outcome of tibial plateau fractures depends a lot on stable osteosynthesis. It require an exact knowledge of the spatial configuration of the fracture. Our objective is to describe fracture plane base on computer tomography.

Methods: We used Schatzker's three-dimensional classification to analyze computed tomography of patients admitted for tibial plateau fractures at the University Hospital Center of Oujda between January 2012 and August 2020.

Results: We found 94 fractures, mostly type II and VI with 3 unclassifiable fractures. The anterolateral compartment is the most often affected. The overall tibial plateau coronal fracture lines was 14.89% and is most common among type IV.

Conclusion: Characterization of complex tibial plateau fractures with use of the main shear presented in this study may be more reliable for communication among surgeons, comparison of studies, preoperative planning and guiding the surgical approach and specific fixation techniques.

Keywords: Tibial Plateau; Classification; Schatzker; Three Dimensional; Computed Tomography

1. Introduction

Tibial plateau fractures are articular injuries which have a broad spectrum of clinical presentations and are frequently associated with long term complications [1]. The complete understanding of the personality of these fractures is the key element in the decision-making process when choosing the best possible treatment [2]. Although many classification systems have been published, Schatzker and AO/OTA are the most studied regarding their reliability. In most studies of reliability using only plain radiographs, the reliability of Schatzker and AO/OTA classification systems was rated as fair or moderate [3]. Lately Schatzker et al proposed a revised three-dimensional complement to the Schatzker classification, which not only provides the axial, coronal, and sagittal morphology of the tibial plateau but also the mechanisms of injury and the exact spatial localization of the main fracture planes [4]. In this study, we applied this extension to a large series of tibial plateau fractures to improve understanding of this challenging injury.

* Corresponding author: Orestes Oluwafemi Zoffoun
Department of Orthopedic Trauma, University hospital center of Oujda, Morocco.

2. Patients and Methods

2.1. Patients

Between January 2012 and August 2020, a total of 125 patients with a tibial plateau fracture were treated at the university hospital center of Oujda (Morocco) and retrospectively analyzed. Of these cases, 19 had to be excluded, as there was no pre-operative computed tomography (CT) scan available. Another 8 were excluded due to an extra-articular fracture manifestation (OTA/AO type A). Other exclusion criteria were pathologic fractures or old fractures; periprosthetic fracture and patients younger than 18 years of age. After exclusion, a total of 94 cases were identified from our institution database. All the radiographs and CT film have been evaluated by the same surgeon to determine fracture plane. All the tibial plateau fractures were classified on the basis of the modified three-dimensional Schatzker classification system. Other factors, such as age, gender, occupation, and mechanism of injury, were also explored.

2.2. Modified three-dimensional Schatzker classification system

The surface of the tibial plateau is divided into two halves, anterior and posterior by a virtual equator. On the lateral side of the knee, the anatomical reference is the lateral tubercle of the fibula, which corresponds to the insertion of the fibular collateral ligament. On the medial side of the joint, the virtual equator intersects the tibial plateau posterior to the attachment of the superficial medial collateral ligament, which also coincides distally with the posterior tibial crest. The glenoid cavities of the tibia are anatomically separated by the eminence and intercondylar areas, so the added virtual equator splits the proximal tibia into four asymmetrical articular quadrants. The six principle fracture types of Schatzker remain the same .A new set of modifiers "A" (anterior) and "P" (posterior) are added to denote the quadrants involved in the six principle types (figure 1). Split wedge fractures of the tibial plateau will disrupt the articular rim at two points and will exit the metaphysis distally to the joint, at the apex of the wedge. The points where the wedge bisects the rim are identified by lowercase letters which denote the location or the points in relationship to the virtual equator, namely anterior ("a") or posterior ("p"). The third point where the fracture exits at the metaphyseal area is denoted as "x". This metaphyseal exit point could be anterior (ax) or posterior (px). These three points, being two on the rim and one on the metaphysis, determine the main fracture plane. In case of unicondylar fracture types, the new denotation of the fracture will include the Roman numerals, which describes the lateral column (I to III) or the medial column (IV), and the upper-case letter A (anterior) or P (posterior). In case of bicondylar fractures types, attention must be paid to each column of the tibial plateau, medial and lateral, and determine which quadrants are compromised in each column. The new denotation of the fracture includes the Roman numerals (V or VI), and the spatial location of the main fracture plane noted with an upper-case letter (A and/or P) in each of the two anatomical columns, lateral (L) and medial (M) [4]. An example is shown in figure 2.

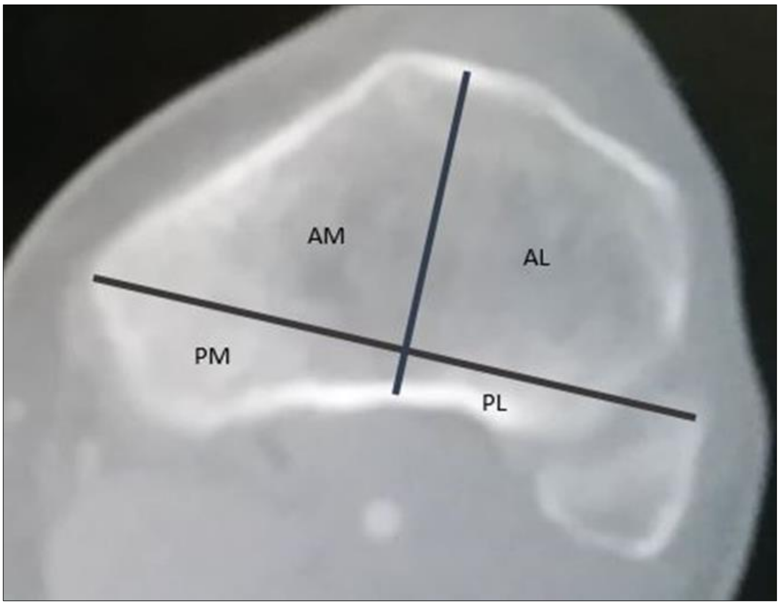

Figure 1 The anatomical quadrants of the tibial plateau

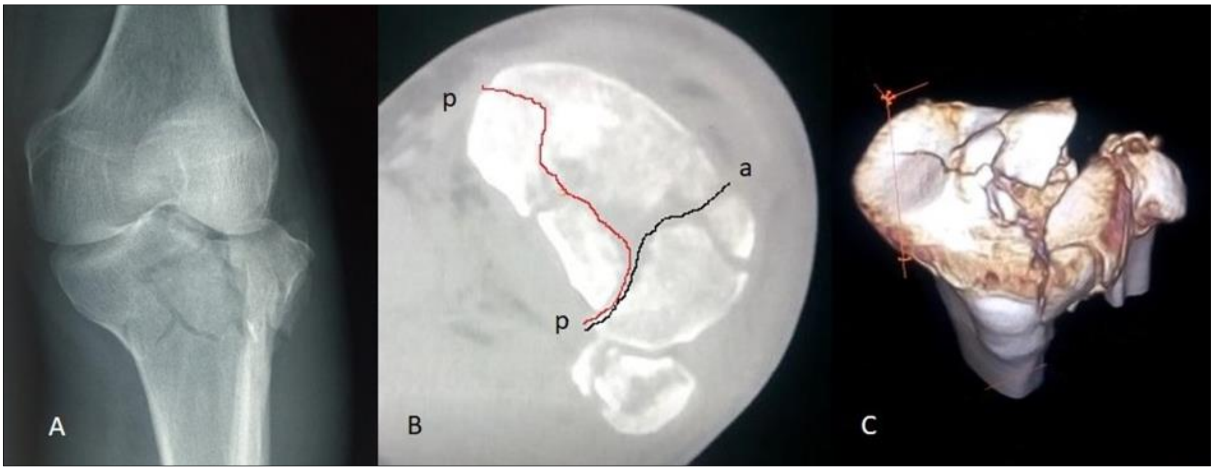

Figure 2 2A: X-ray of a type VI fracture, 2B: axial CT scan of the same fracture showing articular fractures lines , in black (a, p, ax) and in red a fracture with a frontal line (p, p, px) which separates the entire posterior border, divided by a secondary line into posterolateral and posteromedial fragments. 2C: three-dimensional reconstruction, schatzker classification: Type VI AL + PL + PM

3. Results

Over the 8-year period, 93 patients were identified with tibial plateau fractures. There were 68 (73.1%) men and 25 (26.9%) women with an average age of 46.19+/-15. years. A total of 49 (52.13%) cases were left injuries, 43 (45.74%) cases were right injuries, and 1 (2, 13%) case was bilateral injury.

The age group with the highest proportion of tibial plateau fractures is that of 45 to 55, with more men than women. Above 75, women are mainly affected. Figure 3

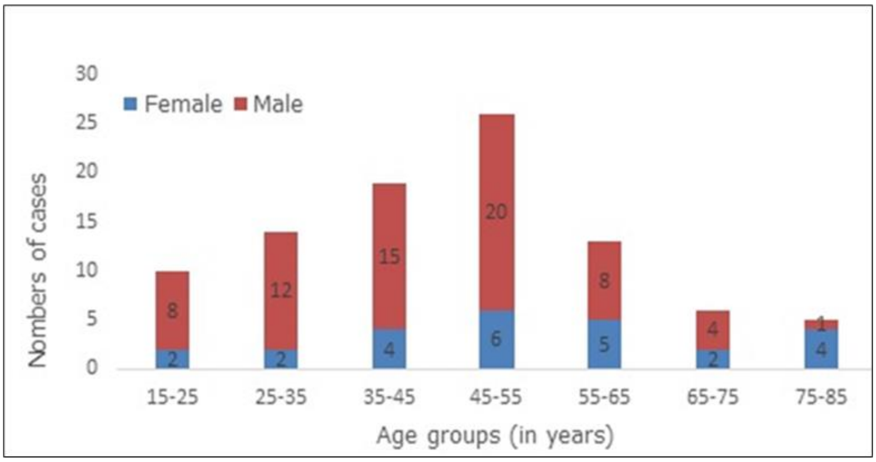

Figure 3 Distribution of age

A total of 77 patients sustained tibial plateau fractures as a result of traffic accidents; there were 4 falls from height, 15 slips, trips or falls at home and 1 sport injury.

The distribution of fractures according to schatzker classification is summarized in figure 4

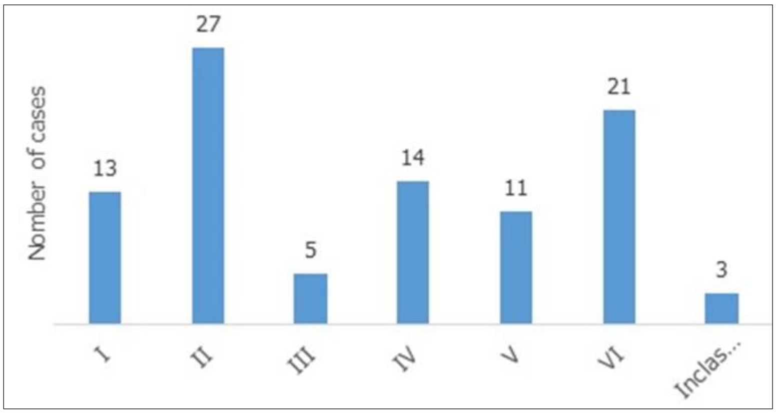

Figure 4 Fractures classification according to Schatzker

- Type I fractures representing 13.8% constantly split the lateral tibial plateau by an anteroposterior line with a distal point at the level of the anterior cortex (a,p,ax).
- Split wedge depression fracture of the lateral plateau (Type II) are the most common fracture (28.7%). Isolated anterolateral quadrant involving is typical and account for 88.8%. The fracture plane is often the same as for type I fracture(a,p,ax) but a second anterior to posterior oblique fracture line (a,p,px) or posterior coronal shear(p,p,px) is associated respectively in 7.4% and 3.7%, detaching a posterolateral fragment. The fracture lines are described in the table.
- Type III isolated depression of lateral tibial plateau are unfrequent with just 5 cases. Depression was either anterior or posterior with 3 anterior (type III A) and 2 posterior (type III B). Two anteromedial depression were unclassifiable according to the Schatzker classification.
- Type IV represent 14.9% of the fractures. This is a medial tibial plateau split fracture. It isn't a mirror of the type I fracture. For the most part, the fracture line exits through the posterior cortex, making it more prone to posterior sliding. It's also the only type with isolated coronal fracture line (p, p, px), present in 2 cases. The fracture lines are described in the table.
- Type V (11.7%), is a bicondylar tibial plateau fracture, where there is continuity between the epiphysis and the diaphysis. it typically includes an anterolateral fragment associated with a posteromedial fragment with sagittal or coronal shear. In nearly 50% of cases, the fracture line of the medial segment is frontal. 2 cases of exclusives posteromedial and posterolateral shear have been noted. The fracture lines are described in the table.
- Type VI (22.3%) is a bicondylar fracture with complete dissociation between the epiphysis and the diaphysis. This is the most common fracture after type II fracture. When the fracture is simple, it often has the shape of an inverted T detaching two large antero or posteromedial fragments and an anterolateral fragment when it passes through the level of the tibial spines, or only affects the lateral compartment while passing through. In more complex fractures, a secondary fracture line splits the medial or lateral compartment (figure 2). The frequency of coronal fracture is 12.8%. The third unclassifiable fracture corresponds to a type VI fracture whose extreme comminution made it impossible to describe the fracture lines according to the schatzer's 3D classification. The overall tibial plateau coronal fracture lines was 14.89%.

4. Discussion

Brunner et al. demonstrated that CT improves the intra- and inter-observer reliability of Schatzker and AO/OTA classification systems [5].Two-dimensional CT allows for a better characterization of the main fracture planes as compared to plain radiographs. Also, there is an increasing understanding of the three-dimensional character of tibial plateau fractures and open reduction and internal fixation is rather based on fracture assessment in the frontal, sagittal, and axial plane with use of CT scans and/or magnetic resonance imaging [6, 7]. Since 2010, four main classifications have been described for a better understanding of the articular involvement of complex fractures of the tibial plateau. That of Luo et al with the three-column concept, adjust by Chang et al in four quadrants concept for posterolateral and the posteromedial differentiation, that of Krause et al in ten segments and lately schatzker's three-dimensional extension [4,7,8,9].

The six type Schatzker fracture classification based on Plain radiographs allow for the understanding of the mechanism of injury [10]. Extension of the classification to the third dimension by the means of CT gives us a detailed information about the exact location of the main fracture plane in each of the four anatomical quadrants which have been defined [4].In the current study, we were able to identify the most frequently affected segments of the articular surface of intra-articular tibial plateau fractures according to the modified Schatzker classification.

As originally described by Schatzker, type I pure cleavage fracture are typical wedge shaped fragment with almost an anterior to posterior shear without comminution [10].

Also, lateral tibial plateau split-depression fracture (Schatzker type II) is the most common fracture type encountered clinically, and accounts for 25–33 % of all tibial plateau fractures, as found in our study (28.7%) [7,10,11,12]. We distinguish two main fracture line (a, p, px) or (a, a, ax), depending on the presence of a posterior rim discontinuity. The fracture can be simple or complex with an anterolateral fragment and a posterolateral fragment. The presence of a free postero-lateral fragment is important to note for the choice of the approach and for optimal implant positioning as the fragment are hidden by the head of the fibula. But we did not find an isolated posterolateral fragment as described by Chen P. et al [13]. As well, we found 11.1% of posterolateral fragment which is much lower than that of Qilin Zhai et al, who found 44.1% [14].

Although the Schatzker classification allows a precise description of the fracture lines, it doesn't allow to specify neither location of the depression nor of its depth, so it doesn't add more to the description of type III fractures. Depression can be anterior, posterior or both.

Table 1 Fractures features among type II, IV, V and VI

Type II fracture		**Type IV fracture**	
	Percentage		**Percentage**
A (a, a, ax)	33.3	A (a, p, ax)	21.4
A (a, p, ax)	55.6	P (a, p, px)	57.1
A (a, p, ax) + P (a, p, px)	7.4	P (p, p, px)	14.3
A (a, p, ax) + P (p, p, px)	3.7	A (a, a, ax) + P(p, p, px)	7.1
Type V fracture		**Type VI fracture**	
	Percentage		**Percentage**
AL (a, p, ax) + PM (a, p, px)	27.3	AL	14.3
AL (a, p, ax) + PM (p, p, px)	27.3	AL+ PM	23.8
AL(a, a, ax)+ PM (a, p, px)	9.1	AL+PL+PM	14.3
PL(a, p, px)+ PM (a, p, px)	18.2	AL+PL+AM	9.5
AL+PL+PM (p, p, px)	9.1	AL+AM+PM	9.5
AL+PL+AM+PM (p, p, px)	9.1	AM+PM+PL	4.8

According to Schatzker's classification, type IV fracture is a unicondylar medial fracture [10]. However, through our study, we observed frequent involvement of both the medial and the lateral condyle in Schatzker type-IV fractures, which is inconsistent with the assumption of a unicondylar medial fracture. The posteromedial fragment, is a spectrum of fracture lines ranging from a parallel, to an oblique, to an anteroposterior line orientation with respect to the posterior femoral condylar axis, as described by Barei and colleagues [15]. An arbitrary cutoff between parallel and oblique fractures lines would distinguish the "classic" posteromedial shear fracture (a coronal fracture line exiting on the medial side from a bicondylar tibial plateau fracture) from the posterior shear-type fracture (involving the posterior aspect of the medial and lateral condyles). Previous studies have shown that these bicondylar posterior shear-type fractures do not fit into the type-IV, V, or VI category in the Schatzker classification. Weil and colleagues classified isolated posteromedial shear fractures as Schatzker type IV and a bicondylar shear-type fracture in the sagittal plane as Schatzker type V or VI [16]. Although the frequency of posteromedial fragments in schatzker bicondylar fractures V (100%) and VI (52.8%) is as common as in literature, 30-65% [15, 17], fractures with frontal features are less frequent.

Hence the need for an exact description for a distinction between different anatomical forms. Especially since, fractures with coronal shear must be treated by a posterior approach or by antero-posterior lag screw when their size allows it.

Another important finding of our investigation was that the highest proportional age group of tibial plateau fractures was 45–54 years, which is similar to the findings of Zheng et al [18]. For young adult males, this is associated with an increasing risk of high-energy trauma, such as traffic accidents, falls from height, and serious crashes as, which, in turn, lead to serious tibial plateau fractures. The phenomenon of peak age delay for females may be due to the high prevalence of osteoporosis among women, especially following menopause [19]. Osteoporosis causes bones to become brittle, which can often be accompanied by comminuted fractures, when compared with young adults with the same trauma.

5. Conclusion

The modified schatzker classification allows an exact description of fractures lines of type I, II, IV and simple fractures of type V and VI. For type V and VI complex fractures, it merges with the four quadrants classification, allowing the segments affected to be specified. Characterization of tibial plateau fractures with use of the main features used in this study is more reliable for communication among surgeons, comparison of studies, preoperative planning and guiding the surgical approach and specific fixation techniques.

Compliance with ethical standards

Acknowledgments

I'd like to thank Professor A. Najib and Professor H. Yacoubi, my research supervisors, for their patient instruction, passionate support, and constructive criticisms of this study effort.

Disclosure of conflict of interest

The authors have no conflicts of interest to declare.

Authors' contribution

Each author made significant individual contributions to the development of this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Elsoe R, Larsen P, Nielsen NP, Swenne J, Rasmussen S, Ostgaard SE. Population-Based Epidemiology of Tibial Plateau Fractures. Orthopedics. Sep 2015; 38(9): e780-6.

[2] Nicoll EA. Fractures of the tibial shaft. A survey of 705 cases. *J Bone Joint Surg Br. 1964*; *46*: *373*e*87*.

[3] Zhu Y, Hu CF, Yang G, Cheng D, Luo CF. Inter-observer reliability assessment of the Schatzker, AO/OTA and three-column classification of tibial plateau fractures. J Trauma Manag Outcomes. 2013 Sep 11;7(1):7. doi: 10.1186/1752-2897-7-7. PMID: 24025650; PMCID: PMC3848575.

[4] Kfuri M, Schatzker J. Revisiting the Schatzker classification of tibial plateau fractures. Injury. 2018 Dec;49(12):2252-2263. doi: 10.1016/j.injury.2018.11.010. PMID: 30526924.

[5] Brunner A, Horisberger M, Ulmar B, Hoffmann A, Babst R. Classification systems for tibial plateau fractures; does computed tomography scanning improve their reliability? Injury. 2010 Feb;41(2):173-8. doi: 10.1016/j.injury.2009.08.016. Epub 2009 Sep 9. PMID: 19744652.

[6] Molenaars RJ, Mellema JJ, Doornberg JN, Kloen P. Tibial Plateau Fracture Characteristics: Computed Tomography Mapping of Lateral, Medial, and Bicondylar Fractures. J Bone Joint Surg Am. 2015 Sep 16;97(18):1512-20. doi: 10.2106/JBJS.N.00866. PMID: 26378267.

[7] Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. J Orthop Trauma. 2010 Nov;24(11):683-92. doi: 10.1097/BOT.0b013e3181d436f3. PMID: 20881634.

[8] Chang SM, Hu SJ, Zhang YQ, Yao MW, Ma Z, Wang X, Dargel J, Eysel P. A surgical protocol for bicondylar four-quadrant tibial plateau fractures. Int Orthop. 2014 Dec;38(12):2559-64. doi: 10.1007/s00264-014-2487-7. Epub 2014 Aug 30. PMID: 25172362.

[9] Krause M, Preiss A, Müller G, Madert J, Fehske K, Neumann MV, Domnick C, Raschke M, Südkamp N, Frosch KH. Intra-articular tibial plateau fracture characteristics according to the "Ten segment classification". Injury. 2016 Nov;47(11):2551-2557. doi: 10.1016/j.injury.2016.09.014. Epub 2016 Sep 6. PMID: 27616003.

[10] Schatzker J, McBroom R, Bruce D. The tibial plateau fracture. The Toronto experience 1968--1975. Clin Orthop Relat Res. 1979 Jan-Feb;(138):94-104. PMID: 445923.

[11] Kennedy JC, Bailey WH. Experimental tibial-plateau fractures. Studies of the mechanism and a classification. J Bone Joint Surg Am. 1968 Dec;50(8):1522-34. PMID: 5722848.

[12] Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audigé L. Fracture and dislocation classification compendium - 2007: Orthopaedic Trauma Association classification, database and outcomes committee. J Orthop Trauma. 2007 Nov-Dec;21(10 Suppl):S1-133. doi: 10.1097/00005131-200711101-00001. PMID: 18277234.

[13] Chen P, Shen H, Wang W, Ni B, Fan Z, Lu H. The morphological features of different Schatzker types of tibial plateau fractures: a three-dimensional computed tomography study. J Orthop Surg Res. 2016 Aug 27;11(1):94. doi: 10.1186/s13018-016-0427-5. PMID: 27567608; PMCID: PMC5002333.

[14] Zhai Q, Luo C, Zhu Y, et al. Morphological characteristics of split-depression fractures of the lateral tibial plateau (Schatzker type II): a computer-tomography-based study. Int Orthop. 2013;37(5):911-917. doi:10.1007/s00264-013-1825-5

[15] Barei DP, O'Mara TJ, Taitsman LA, Dunbar RP, Nork SE. Frequency and fracture morphology of the posteromedial fragment in bicondylar tibial plateau fracture patterns. J Orthop Trauma. 2008 Mar;22(3):176-82. doi: 10.1097/BOT.0b013e318169ef08. PMID: 18317051.

[16] Weil YA, Gardner MJ, Boraiah S, Helfet DL, Lorich DG. Posteromedial supine approach for reduction and fixation of medial and bicondylar tibial plateau fractures. J Orthop Trauma. 2008 May-Jun;22(5):357-62. doi: 10.1097/BOT.0b013e318168c72e. PMID: 18448992.

[17] Higgins TF, Kemper D, Klatt J. Incidence and morphology of the posteromedial fragment in bicondylar tibial plateau fractures. J Orthop Trauma. 2009 Jan;23(1):45-51. doi: 10.1097/BOT.0b013e31818f8dc1. PMID: 19104303.

[18] Zheng ZL, Yu YY, Chang HR, Liu H, Zhou HL, Zhang YZ. Establishment of Classification of Tibial Plateau Fracture Associated with Proximal Fibular Fracture. Orthop Surg. 2019 Feb;11(1):97-101. doi: 10.1111/os.12424. Epub 2019 Feb 8. PMID: 30734492; PMCID: PMC6430455..

[19] Dhanwal DK, Cooper C, Dennison EM. Geographic variation in osteoporotic hip fracture incidence: the growing importance of asian influences in coming decades. J Osteoporos. 2010 Aug 2;2010:757102. doi: 10.4061/2010/757102. PMID: 20981334; PMCID: PMC2957223.