# Controversies in Management of High Energy Tibial Plateau Fractures: A Systematic Review

Osborne A, Barry M

March 2017
Volume 14
Issue 1
Doctors Academy Publications

High energy, particularly bicondylar, fractures of the tibial plateau offer a significant challenge to the orthopaedic surgeon since they are associated with a high level of morbidity and complications post-operatively.


# WJMER

World Journal of Medical Education and Research

An Official Publication of the Education and Research Division of Doctors Academy


The 8th International Medical Summer School Manchester: A Report

Paediatric Surgical Intervention In Sierra Leone: A Retrospective Study of 204 Patients

Controversies in Management of High Energy Tibial Plateau Fractures: A Systematic Review

Are We Selecting Patients Appropriately for ITU Following Major Abdominal Operation? – A Retrospective Review

Abstracts from the 7th International Academic and Research Conference 2017

DOCTORS ACADEMY

BETTER EDUCATION. BETTER HEALTH.


ISSN 2052-1715

Literature Review
DAUIN 20170114



# Controversies in Management of High Energy Tibial Plateau Fractures: A Systematic Review

Osborne A, Barry M

**Institution**
Bartshealth NHS Trust
United Kingdom

***WJMER, Vol 14: Issue 1, 2017***

**Abstract**

**Introduction**: High energy, particularly bicondylar, fractures of the tibial plateau offer a significant challenge to the orthopaedic surgeon since they are associated with a high level of morbidity and complications post-operatively. Currently two treatment modalities are used in management of these cases: open reduction and internal fixation (ORIF) or external fixation with a circular frame. The aim of this review is to compare treatments and present any differences in outcome, plus advantages or disadvantages of either fixation, as currently there is no accepted best treatment.

**Methods**: Four databases were searched using the Boolean search terms associated with tibial plateau fractures and operative fixation. Databases searched were PubMed, Web of Science, Cochrane database and Science Direct.

**Results**: 122 papers were returned by the search. However, only six papers were directly comparing ORIF to external fixation and met the inclusion criteria.

**Conclusion**: Evaluating the literature, it seems long term outcomes of both surgical modalities do not differ significantly. Differences are notable in the short term, particularly in the rate of complications. It becomes apparent that ORIF is associated with complications of greater consequence, requiring further more invasive surgeries in comparison to circular frame fixation. Circular frame use also resulted in a shorter stay in hospital on average. On balance, external fixation with circular frame could be advantageous over ORIF due to its benefits in the short term for patient and identical outcomes long term; and should be adopted as the best practice approach.

**Key Words**
Bone Plates; Tibial Fractures; Tibial Plateau; Fracture Management; ORIF

**Corresponding Author:**
Mr Alexander Osborne; E-mail: alex_osborne@outlook.com

## Introduction

The current best management of tibial plateau fractures is often subject to much debate within orthopaedic departments and literature, with the most controversy surrounding the high energy fractures. The aim of this review will be to present the current management of high energy tibial plateau fractures found in the literature and to draw conclusion on interventions with the best outcomes, should this become apparent.

## Aetiology

Fractures of the tibial plateau account for 1.3% of fractures, and are more common in men than women[1]. The young and the old are both affected but the mechanism of injury is significantly different between the two patient populations. Most commonly, the low energy fractures occur in the elderly secondary to osteopenia[2], and can be a consequence of even simple falls in osteoporotic patients[1]. This is demonstrated by a higher incidence of fractures in elderly female patients compared to male counterparts, which is in keeping with a higher incidence of osteoporosis in women than men. Schatzker I-III typically result from a much lower energy trauma than those of IV and above. Due to the lower energy mechanisms of energy, fractures are normally closed fractures and with smaller incidences of comminution. However, this does not mean the fractures are simple and of little consequence to the patient. Schatzker II fractures are most commonly associated with medial collateral ligament injuries[3], demonstrating that, even with a low energy, the mechanism of injury management may not be straightforward. Given the patient population, there are a large number of postoperative complications and approximately a 17% peri-operative mortality rate[4].

In paediatric and adolescent patients tibial plateau fractures are rare, as it is very uncommon to suffer this injury before the closing of the epiphyseal growth plates[5]. In adults these injuries are due to a high energy trauma, such as a fall from height or cases of pedestrian collisions with cars. Approximately 50% of cases are the consequence of road traffic collisions, 17% are from falls and 5% from recreational and sporting activities[1].

## Classification

The first hurdle in management, after initial resuscitation and stabilising of the patient, is to identify the fracture as well as the extent of damage to the joint and surrounding structures. Mechanism of injury is thought to be an initial axial loading of the joint which impacts the articular surface causing fracture. This axial loading is most commonly combined with an angular force, such as in a road traffic collision described above. The addition of this angular force means there is often damage to the metaphysis also; comminution of the metaphysis and articular surface is common[6]. Commonly the medial compartment is split in medio-lateral direction with the main fragment being postero-medial[7]. However, many other possible fracture patterns are possible, demonstrating the need for a common tool to aid classification of these fractures.

Classifying the injury also allows for reliable communication and, using a pattern based system, split between surgeons, about the need for more extensive approach for example. Classification of tibial plateau fractures was first attempted by Schatzker in 1979 and gave rise to his Schatzker classification which is used to date. He analysed the anterior-posterior (AP) radiograph of 94 patients with tibial plateau fractures and, using a pattern based system, split these into six classes[8]. They divided the tibial plateau fractures into: split fracture of the lateral tibial plateau (Type I); split depression of the lateral tibial plateau (Type II); central depression of the lateral plateau (Type III); split of the medial tibial plateau (Type IV); bicondylar tibial plateau fracture (Type V); and dissociation between the metaphysis and diaphysis (Type VI).

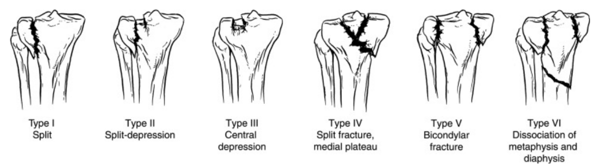


***Figure 1**: Image taken from Berkson EM et al High-energy tibial plateau fractures)*

As mentioned above the Schatzker classification is based on patterns of fracture seen in a series of patients. The classification was also intended to give direction on the management of these fractures. However, with the development of locking plates, for example, the management suggested by Schatzker has been somewhat developed over the years. External fixation or open reduction and internal fixation are the two modalities that are often used in theatres for surgical management of fractures at the higher end of the classification scale.

Five other classifications are also used to describe these fractures. The second most commonly used, however, is the AO classification[9]. The AO classification is used to describe a number of fracture types with different scales being used for different fracture sites. For the tibial plateau, three types are used, with each of these having 3 subtypes, the details of which are shown in Figure 2.

| Type | Subtype |
|---|---|
| A: Non-articular | A1 – Avulsions |
| | A2 – Simple Metaphyseal |
| | A3 – Comminuted Meta-physeal |
| B: Partial Articular | B1 – Pure Split |
| | B2 – Pure Depression |
| | B3 – Split Depression |
| C: Complete Articular | C1 – Simple |
| | C2 – Articular simple, metaphyseal comminuted |
| | C3 – Articular Comminu-tion |

***Figure 2:** Table showing AO Classification adapted from: http://www.orthopaedicsone.com/display/Main/Tibial+plateau+fractures+-+AO+classification*

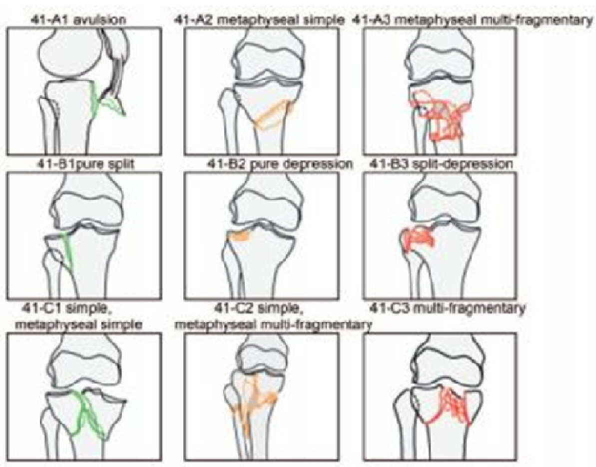


***Figure 3:** AO classification of tibial plateau fractures[10]*

Both of the above classifications have shown to be reliable in the literature and have widespread use in the management of tibial plateau fractures, with the AO classification having a greater intra/inter observer reliability when classified using plain radiograph alone[11]. In the literature it is also noted that the use of computed tomography (CT) increases the reliability of classification when using both the AO and Schatzker classification[12].

As mentioned above, most controversy surrounds the management of the higher energy fractures. These are the Schatzker V and VI, both of which have distinct fracture patterns and a high degree of comminution is commonplace[13]. In addition, with an increase in energy applied to the limb, the degree of associated soft tissue damage increases. As could be expected, the prognosis becomes poorer[14].

### Management Strategies

The initial management of high energy fractures will be focused on resuscitation and assessing the extent of associated soft tissue injuries. Measures should be taken to reduce the swelling surrounding the joint; elevation, compression and possibly joint aspiration. This should not be done in any limb in which compartment syndrome is expected; a four compartment fasciotomy should be performed as soon as possible. Delaying is associated with high rate of further complications such as injury to the common peroneal nerve[15]. Traction may also be considered in this early management stage either as a temporary or definitive measure in a certain number of plateau fractures. The decision can also be made as to whether to place a temporary spanning external fixator to the same effect as traction[16]. A temporary fixator can be a useful aid to management. It allows for some degree of soft tissue healing before a more definitive surgical fixation and, as it provides traction, it can offer more information on fracture morphology as visualisation of the site is improved on imaging[17].

Definitive surgical management is often carried out at a later date than the initial injury since many patients may be unstable due to polytrauma, with many systems being affected. Once the patient is more stable and fit for surgery, there are a number of possible approaches for fixation which are broadly split into two modalities: open reduction and internal fixation or external fixation.

### External Fixation – Circular/Ring External Fixator

This is a definitive form of fixation in which a number of circular rings are fixed from the level of proximal fibular to distal. The first stage of this approach is to reduce the fracture components. As these are normally Schatzker V/VI, there is often a high degree of comminution; reduction can be aided by the use of distractors. The medial plateau is generally significantly less comminuted so reduction should be started here before proceeding to lateral. Following reduction, bone grafting may be necessary to prevent collapse of the reduced articular surface. The insertion of wires can now take place, beginning with the proximal ring and proceeding distally. Once all rings are in place, reduction should be checked under image intensifier before the frame is tightened.

### External Fixation – Hybrid Frame

Hybrid frames are, in essence, a combination of two forms of fixation: a circular frame that surrounds the leg on a level with fibular head. The frame is then anchored by a tube that is drilled into the distal tibia. A small incision is typically made in the anteromedial aspect of the tibial metaphysis. Following this, a K wire can be inserted through the tibial cortex to allow the depressed fragments to be pushed up. This is then held in place with reducing forceps. Following this, a small lateral incision can be made and as many K wires as required can be inserted to provide adequate stabilisation of the now reduced articular fragments.

Schanz pins are then inserted into the diaphysis of the tibia and the tube that will be attached to the distal tibia is connected to these pins. Before tension is applied, reduction should be achieved and checked under image intensifier. Once satisfactory, the tube to the distal tibia is fixed before the frame is tightened.

### Internal Fixation

Internal fixation can be achieved by a number of means: arthroscopic assisted fixation, traditional double plating, or biologic fixation. Biologic fixation can be screw fixation, minimally invasive plate osteosynthesis, or least invasive stabilisation system (LISS)[16]. Approaches will vary with the chosen method but will involve an incision to gain access before reduction of the articular surface. Similar to the external fixator method described above, distracters can be used for the purpose of aiding reduction. After reduction, preliminary fixation can be done using K wires, before fixation with lag screws or positioning screws, depending on the method of fixation being used.

If LISS is being used, positioning screws will be inserted before introduction of the LISS plate. The LISS plate will be slid in constant contact with the bone in the distal direction. Once in the correct position it will be fixed to the distal tibia. The internal fixator will be inserted using a guide handle, into the epiperiosteal space between the anterior tibial muscle and the periosteum. With the use of this plate, it is essential to dissect carefully when fixing the distal portion to avoid injury to the superficial peroneal nerve.

### Complications

Both open reduction and internal fixation and external fixators can result in different complications. However, some are common between the two procedures. For example, infection is a risk in both but significantly higher in ORIF up to 12% of cases[18]. Infection is one of the most immediate post-operative complications after intraoperative blood loss. It is a common reason for revision procedures and further unplanned surgical procedures after initial permanent fixation. Traditional ORIF approach not using the LISS involves extensive soft tissue striping to allow for adequate exposure and, as such, is associated with higher rates of infection[19]. Circular fixators are not without risk of infection, most notably pin track sepsis. However, measures can be taken to reduce infection rates. The introduction of low energy insertion and a standardised post-operative care has been shown to reduce the incidence of pin track sepsis[20].

A further immediate complication of ORIF is peroneal nerve palsy. As mentioned in the surgical technique section above, this is due to the course of the peroneal nerve over the end of the distal tibia where the lower part of the plate is fixed. Peroneal nerve palsy can cause significant morbidity; foot drop causes gait problems and difficulties in walking. This complication can be seen using circular fixation methods but rates are higher in ORIF[18].

Long term complications that both procedures have in common are malunion and non-union. However, this is relatively uncommon[21]. Both methods of fixation are at risk of losing the reduction of the articular surface upon weight bearing. This can occur even with plate in situ and a further operation with its associated risks is required. With a circular fixator, however, a small adjustment can often be made to correct and avoid the need for extensive further surgery[19]. Associated with a change in the articular surface is joint stiffness, but is not confined to drops in the reduced surface and can occur even with a perfect anatomical reduction.

Patients consenting for permanent fixation of a tibial plateau fracture should be also be warned of the following: incomplete relief of pain and a loss of function, skin loss, post-traumatic arthritis, heterotopic ossification and compartment syndrome[18].
Currently in the literature there are a number of studies that compare methods of fixation of high energy tibial plateau fractures in terms of outcome. However, little conclusions are reached in what may be best practice to achieve the best functional outcome for patients. The following discussion will aim to present relevant literature on the best management of tibial plateau fractures and discuss the benefits of different surgical approaches.

### Method

Existing systematic reviews were read before deciding on the most relevant search terms to return results of papers that compared the two surgical methods. Following this background reading, it was decided that the terms bicondylar, tibial plateau fractures, open reduction and internal fixation, and external fixation would be used. The inclusion of bicondylar as a search term was used in the hope that papers returned would focus on the Schatzker 5/6 fracture patterns as these higher energy fractures were the debate centres. Four databases were searched using the Boolean search method to ensure only relevant papers were returned. These were PubMed, Cochrane database, Web of Science and Science Direct. The final search term entered was Tibial plateau fracture AND bicondylar AND open reduction and internal fixation AND external fixation. Once the initial search had returned the results, any papers that were not written in English were immediately discarded. However, due to a small number of papers that had made direct comparisons, a broad range of 25 years was used.

### Results

Searching the three databases returned 122 papers. The breakdown of the search was 15, 81, 24 and 2 for PubMed, Science Direct, Web of Science and Cochrane database respectively. Literature returned by the search was reviewed for relevance by reading the abstracts. The result was that twelve papers met the criteria of comparing two cohorts of patients with high energy tibial plateau fractures, treated with either open reduction and internal fixation or a form of external fixation. A further six were removed since they were duplicates returned by another database, leaving six final papers for analysis. The details of the papers are given in the table below.

| Paper | Title | Author | Year |
|---|---|---|---|
| 1 | Open reduction and internal fixation compared with circular fixator applications for bicondylar tibial plateau fractures: Results of a multicentre, prospective, randomized clinical trial | Canadian orthopaedic trauma society | 2006 |
| 2 | Bicondylar tibial fractures: Internal or external fixation? | Kumar, G | 2011 |
| 3 | Open reduction and internal fixation compared with circular fixator application for bicondylar tibial plateau fractures. Surgical technique | Hall, J.A. | 2009 |
| 4 | Open reduction and internal fixation versus hybrid fixation for bicondylar/severe tibial plateau fractures: a systematic review of the literature | Mahadeva, D | 2008 |
| 5 | Outcomes following the treatment of bicondylar tibial plateau fractures with fine wire circular frame external fixation compared to open reduction and internal fixation: A systematic review | Boutefnouchet, T | 2015 |
| 6 | Internal versus external fixation of bicondylar tibial plateau fractures. | Malik AR | 1992 |

***Paper 1***

Carried out a multicentre, randomised control trial and compared open reduction and internal fixation with percutaneous/limited open fixation with a circular fixator being applied in displaced bicondylar tibial plateau fractures. 83 fractures were entered into the trial and randomised to receive one surgical procedure. Outcome measures consisted of hospital for special surgery (HSS) knee score, Western Ontario and McMaster universities osteoarthritis index (WOMAC) score, and the short form general health survey and finally recording of complication and reoperation rates. Results showed that both surgical methods provided adequate reduction, but circular fixator resulted in shorter hospital result and a faster return to function, measured by 6-month activity level (p=0.031). The pain scores (WOMAC) measured at two years were not significantly different (p=0.923). It is important to note that those in the ORIF group were subject to much higher significant complication and reoperation rates. The conclusion was that circular fixator is an attractive option for the higher energy, difficult-to-treat Schatzker 5 and 6 fractures.

***Paper 2***

Presented a discussion of the different surgical modalities available for bicondylar tibial plateau fractures and attempted to devise a protocol for the treatment of these complex fractures. Protocol consisted of a CT scan after the application of a spanning external fixator, allowing for assessment of the fracture pattern. Method used to restore the articular surface was common for both modalities; chosen method being indirect reduction using traction and ligamentotaxis. If fracture pattern was stable, then the authors used internal fixation, assuming the soft tissue allowed. If it was unstable, circular fixator was used. This choice was made as the circular frame allows for a greater fine tuning of the alignment of the tibia. Authors concluded that surgical management should be guided by the extent of associated soft tissue injury and the fracture pattern type.

***Paper 3***

Carried out again by the Canadian Orthopaedic Trauma Society, this paper follows on from their RCT published in 2006 and Paper 1 above. It presents an updated protocol for surgical technique for both open reduction and internal fixation, and minimal invasive reduction with circular external fixator. In a closing paragraph by the authors, there is an update to the previous paper released in 2006 stating that the two methods of surgical fixation can be used in a complementary fashion. The final conclusion was much the same as the protocol of Paper 2: fractures that are unstable with significant soft tissue swelling should be treated with circular fixator. Those with less severe intra-articular fragmentation can be treated with open reduction and internal fixation. It is worth noting that the author advocates the use of the minimally invasive techniques for ORIF to prevent extensive soft tissue stripping and to avoid complications such as wound breakdown.

***Paper 4***

This paper is the first of two review articles returned by the search. This paper also found five articles in the literature relating to its search parameters. Very similar search terms were used to locate this review. The authors, however, included laboratory studies in their article. Results of the review were six conclusions that emerged from the five papers. First recommendation was in line with the other papers above in that the soft tissue status needs to be evaluated carefully before accepting a certain management pathway. Hybrid fixation was also reviewed in this article and was found to have very good outcomes in the short term when measured by knee range of motion and HSS knee scores. The issue of compliance and acceptance with hybrid frames was an area authors thought needed to be investigated as past case series have found acceptance of hybrid frames to be low and not just in fixation of proximal tibia. Conclusion was that long term sequelae was generally poor for both methods of fixation and further long term studies should be the focus.

***Paper 5***

The second review article published in 2015 returned by our search; used terms very similar to those in this paper and included five articles that made direct comparisons between open reduction and internal fixation and external fixation. External fixation method examined in this review was fine wire fixation with a circular fixator. On reviewing the literature, the authors concluded that fine wire circular fixation offered good outcomes with modest advantage in terms of soft tissue viability. The authors also concluded that there needs to be more research into the newer LISS/osteosynthesis plates to determine if they confer an advantage[23].

***Paper 6***

Reviewed cases of tibial plateau fracture treated surgically at their centre. Retrospective in nature, it evaluated the outcomes of eight patients who underwent open reduction and internal fixation or indirect reduction and application of a Monticelli-Spinelli circular fixator. No notable difference was noted in the time to union between the two groups. In complications is where the two groups differ, most significantly in rates and severity of infection. The three patients treated with circular fixator developed pin tract infection but these resolved quickly with wound care and antibiotics. In addition, in this group no deep infections developed. This was in contrast to the ORIF group in which four of whom required further interventions. Two developed osteomyelitis requiring further treatment, a further patient with osteomyelitis needed a knee arthrodesis, and the final patient developed a chronic osteomyelitis and a subsequent varus deformity. The paper concluded that external reduction and circular fixator had a smaller incidence of significant infections and limited surgical insult to surrounding soft tissues.

## Discussion

When comparing surgical interventions, the key issue to be evaluated in all comparisons is the impact of surgery on patients' quality of life and the associated morbidities, if any. As mentioned earlier, with the higher energy tibial plateau fractures a definitive surgical intervention is most often required as most cannot be managed using a conservative approach. Different articles in the literature use different outcome measures to assess interventions. The main focus is how the knee returns to function in a biomechanical sense, the pain experienced by the patient, and the quality of life postoperatively. These can be measured by post-operative knee range of motion, HSS knee score, and short form SF-36 health status questionnaire respectively[24].

It is of note that the circular fixator group seemingly return to function and weight bearing quicker than their ORIF counterparts. HSS knee scores at six months, as well as number of patients returning to pre-injury activity at six and 12 months, is greater in those treated with circular frame. However, the difference in outcome does not seem to be true by all measures. When using more objective measures such as knee arc motion there is no significant difference noted. Two years post-procedure, there is no difference in the pain, stiffness or functional ability between the two groups. This suggests that using a circular fixator allows patients to mobilise quicker post-operatively and to leave hospital sooner which, in turn, has a positive psychological effect. In essence, their short term scores in terms of pain and function could be better than their ORIF counterparts who will spend more time in hospital on average.

ORIF has a higher rate of further surgical procedures when compared to circular fixators. The multicentre randomised control trial found eighteen patients managed with ORIF required thirty seven further surgical procedures, compared to fifteen unplanned surgical procedures in sixteen patients managed with circular fixators[25]. These surgeries were, for a variety of different and, while it may be a subjective finding, the operations for the ORIF group were of a more extensive nature. The circular fixator group underwent procedures such as pin track debridement, knee manipulation or screw removal. The ORIF group, on the other hand, underwent incision and drainage with plate removal, osteotomy and, in one case, above the knee amputation. This may be just one study but it does show that ORIF seems to be associated with complications of greater consequence than circular frame fixators.

As a consequence of the above complications, when using open reduction and internal fixation the definitive treatment is often delayed, allowing greater time to heal and to increase the viability of the anterior structures. With ORIF a main goal is to avoid extensive soft tissue dissection and to minimise damage to surrounding structure as this can cause devascularisation of bone fragments. This devascularisation can also create soft tissue flaps that can lead to wound breakdown[25]. These concerns are not as prominent, if at all, with the use of an external fixator. We may question what the advantages of internal fixation that warrant this seeming increase in risk and complications are. Much may be down to surgeon preference and the familiarity with the procedure. In terms of reduction, there seems to be little difference between ORIF and a circular fixator when comparing osseous reduction in the two different surgical groups, assuming no significant difference in demographics [25].

The long term functional sequelae from tibial plateau fractures is often poor, especially with extensive intra articular damage seen in the higher energy fractures. The extent that the associated soft tissue injury contributes to poor functional outcome is unclear[24] and is an area for further research; the role of concurrent meniscal injury and collateral ligament injury could be key. A long term study followed up patients postoperatively, the mean follow-up time being 11 years. 286 patients were entered into study and 77% of the patients were treated operatively. Of these, 4.5% underwent a reconstructive procedure for traumatic arthritis during the follow-up period[26]; in comparison to 6.0% of the conservative treatment group. However, the results of this study are limited due to the inclusion of all types of tibial plateau fracture as it is established in the literature that the Schatzker V and VI bicondylar type fractures have a greater incidence of post-traumatic arthritis. Thus, attempting to make direct comparisons between operative and non-operative groups in terms of long term is often subject to confounders as higher energy fractures most often cannot be managed conservatively. Therefore, patients who are more likely to suffer from post-traumatic arthritis will fall into the operative management group. The 10-year survival in the operative and non-operative group was also calculated and these were 97% and 94% respectively.

## Conclusion

Both circular frame external fixation and open reduction and internal fixation are suitable methods for permanent fixation of high energy tibial plateau fractures. Evaluation of the status of the surrounding soft tissue is a crucial step in management and, from the literature reviewed, it seems that fine wire fixation with circular frame may prove the best option in patients with extensive soft tissue injury. If open reduction and internal fixation is still to be carried out in these patients, then it is recommended to allow the soft tissue time to heal before permanent fixation. This can be facilitated with the use of temporary spanning fixator. Evaluating the literature, it seems that circular frame fixation has the best short term outcomes and does seem to offer some advantage in complication rates compared to open reduction and internal fixation. With no differences in long term outcome found in this review between the two methods, it seems that circular frame fixation is advantageous over ORIF due to the benefits to the patient in the short term. Further research should focus on developing surgical technique with circular frame fixation as this should be taken forward as the new best practice approach for these difficult fractures.

## References:

1. Moore TM, Patzakis MJ, Harvey JP. Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. J Orthop Trauma 1987;1-2:97-119.
2. Cole P, Levy B, Schatzker J. Tibial Plateau Fractures. Vol. Skeletal Trauma: Basic science, management and reconstruction, 2009.
3. Bennett WF, Browner B. Tibial plateau fractures: a study of associated soft tissue injuries. J Orthop Trauma 1994;8-3:183-8.
4. Moran CG, Gibson MJ, Cross AT. Intramedullary locking nails for femoral shaft fractures in elderly patients. J Bone Joint Surg Br 1990;72-1:19-22.
5. Thomas C. http://www.achot.cz/detail.php?stat=305 (accessed).
6. Babis GC, Evangelopoulos DS, Kontovazenitis P, Nikolopoulos K, Soucacos PN. High energy tibial plateau fractures treated with hybrid external fixation. J Orthop Surg Res 2011;6:35.
7. Eggli S, Hartel MJ, Kohl S, Haupt U, Exadaktylos AK, Roder C. Unstable bicondylar tibial plateau fractures: a clinical investigation. In: J Orthop Trauma. Vol. 22. United States, 2008:673-9.
8. Zeltser DW, Leopold SS. Classifications in Brief: Schatzker Classification of Tibial Plateau Fractures. In: Clin Orthop Relat Res. Vol. 471, 2013:371-4.
9. Charalambous C, Tryfonidis M, Alvi F, Moran M, Fang C, Samaraji R, Hirst P. Inter- and Intra-Observer Variation of the Schatzker and AO/OTA Classifications of Tibial Plateau Fractures and a Proposal of a New Classification System. Ann R Coll Surg Engl 2007;89-4:400-4.
10. Website A. http://www.aofoundation.org. (accessed).
11. Walton NP, Harish S, Roberts C, Blundell C. AO or Schatzker? How reliable is classification of tibial plateau fractures? Arch Orthop Trauma Surg 2003;123-8:396-8.
12. Gicquel T, Najihi N, Vendeuvre T, Teyssedou S, Gayet LE, Huten D. Tibial plateau fractures: reproducibility of three classifications (Schatzker, AO, Duparc) and a revised Duparc classification. Orthop Traumatol Surg Res 2013;99-7:805-16.

13. Berkson E, Virkus W. High Energy Tibial Plateau fractures. Vol. 14. Journal of the American Academy of Orthopaedic surgery, 2006:20-31.
14. Kennedy JC, Bailey WH. Experimental tibial-plateau fractures. Studies of the mechanism and a classification. J Bone Joint Surg Am 1968;50-8:1522-34.
15. Common peroneal nerve dysfunction: MedlinePlus Medical Encyclopedia. 2015.
16. Vidyadhara S. http://emedicine.medscape.com/article/1249872-treatment (accessed 2015).
17. Hansen M, Pesantez R. https://www2.aofoundation.org/wps/portal/surgery (accessed).
18. http://eorif.com/tibial-plateau-fracture-orif-27535#Anchor-ORIF-47383 (accessed).
19. Mankar SH, Golhar AV, Shukla M, Badwaik PS, Faizan M, Kalkotwar S. Outcome of complex tibial plateau fractures treated with external fixator. In: Indian J Orthop. Vol. 46, 2012:570-4.
20. Ferreira N, Marais LC. Bicondylar tibial plateau fractures treated with fine-wire circular external fixation. In: Strategies Trauma Limb Reconstr. Vol. 9, 2014:25-32.
21. Court-Brown C, McQueen M, Tornetta P. Trauma. Lippincott Williams & Wilkins, 2006.
22. Rull G. http://www.patient.co.uk/doctor/important-complications-of-anaesthesia (accessed).
23. Outcomes following the treatment of bicondylar tibial plateau fractures with fine wire circular frame external fixation compared to open reduction and internal fixation: A systematic review. 2015.
24. Mahadeva D, Costa ML, Gaffey A. Open reduction and internal fixation versus hybrid fixation for bicondylar/severe tibial plateau fractures: a systematic review of the literature. Arch Orthop Trauma Surg 2008;128-10:1169-75.
25. Society TCOT. Open Reduction and Internal Fixation Compared with Circular Fixator Application for Bicondylar Tibial Plateau Fractures. 2006.
26. Mehin R, O'Brien P, Broekhuyse H, Blachut P, Guy P. Endstage arthritis following tibia plateau fractures: average 10-year follow-up. In: Can J Surg. Vol. 55, 2012:87-94.

The World Journal of Medical Education & Research (WJMER) is the online publication of the Doctors Academy Group of Educational Establishments. It aims to promote academia and research amongst all members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from all parts of the world. The journal intends to encourage the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting-edge technology and those who need to innovate within their resource constraints. It is our hope that this interaction will help develop medical knowledge & enhance the possibility of providing optimal clinical care in different settings all over the world.


WJMER

World Journal of Medical Education and Research

An Official Publication of the Education and Research Division of Doctors Academy

ISBN 978-93-80573-62-5

9 789380 573625 >