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Outcome of Proximal Tibia Fractures Treated With Dual Plating - A Retrospective Study

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Abstract: *The management of bicondylar fracture of the proximal tibia is a challenging task and the aim of management is to achieve stable, painless and mobile joint and also to prevent the secondary degeneration of the joint. Open reduction and internal fixation with dual plating in such fractures is beneficial to address fracture fragments in different planes and also to achieve anatomical reduction under direct vision. It also allows to stabilize the fracture which helps in early mobilization of the patient. Early post-op rehabilitation is one the most important factor that play a vital role in outcome of the operated knees by preventing the post-operative stiffness and achieving good range of motion. This study analyses the outcome of bicondylar proximal tibia fracture treated with dual plating in 68 patients. In our series we found 63 % excellent results and 28 % good results, while 7 % and 2% fair and poor outcome respectively.*
Keywords*: Bicondylar, Tibia,*

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I. Introduction

Tibial plateau fractures are challenging, attributing to the fact of their increased incidence, complexity, associated complications, and availability of different treatment options. With increased mechanization and acceleration, traveling is associated with increased incidence and severity of these fractures. Sitting mode of traveling expose the knees directly to the loading forces. Bumper fracture is pedestrian injuries seen when a stationary limb is subjected to injury with a moving object. These subjected forces can cause impaction, angulation, rotation or sheering strain.

In olden times conservative management was the mainstay of treatment which resulted in joint incongruity, early osteoarthritis, knee stiffness. Over a period, our understanding has grown in mechanics of knee joint, mechanics involved in fracture, importance of congruent reduction and stable fixation to facilitate early mobilization, improved implants and improved antibiotic cover against infection. Internal fixation of fractures is an acceptable modality of treatment over conservative management. With availability of various options, the definitive fixation method is still controversial. While open reduction and internal fixation is best method to achieve the goals of anatomical reduction, historically it is associated with higher rate of complications such as increased soft tissue injury and major wound related complications. Alternate methods are described with their own merits and demerits.

In our study we have evaluated the functional outcome of high energy fractures such as Shatzker's type V and type VI tibial plateau fractures treated with use of dual plating and dual approach.

Aim and objectives of this study is to analyse

- The outcome of bicondylar fractures treated with dual plating.
- The role of early mobilization in outcome.
- Associated complications of bicondylar fracture and their treatment.

Treatment history of these fractures follows two centuries ago when Arabs used plaster to immobilize the limb. Till the end of 18th century main mode of treatment was to use splintage. Skin traction was introduced in 1805 by Samuel David in the form of adhesive tape to reduce and maintain these fractures. Detailed description of proximal tibia fracture was first given by Sir Astley Cooper in 1825. Cotton and Berg (1929)[33] were the first to term these fracture as 'bumper fracture' because they were commonly seen in patients hit by motor vehicle. Barr (1940)[31] was the first to describe the mechanism behind proximal tibia fractures. He explained how varus valgus and axial loading can cause different pattern of fractures involving medial, lateral, or both condyles. Palmer(1951)[21] reported his first attempt of treating depressed proximal tibia fracture with the use of bone graft after making a critical window and elevation of the depressed articular surface. In 1952 Wilson

and Jacobs reported their work in depressed and severely comminuted fracture. They attempted reconstruction of the proximal tibial articular surface with the help of patellar articular surface. Results failed to gain popularity amongst the orthopaedic community. Anger treated most minimally displaced fractures with early knee traction mobilization(1956)[4.] Hohl and Luck (1956)[11] treated these fractures surgically, where they reported 72 % of success rate. Lee (1957) [13]attempted to restore the articular surface with the help of inner concave surface of anterior superior iliac crest bone graft. Martin(1960)[16] in his experimental study described the importance of associated soft tissue and ligament injuries with proximal tibia fractures. Mason and Hohl (1967) [10]stated that effective treatment of these fracture is improved with the restoration of articular surface and treatment of associated soft tissue or ligament injuries. Paul S. Rasmussen(1973)[22] introduced open reduction and internal fixation (ORIF) of tibial condylar fractures. Tillman M.Moore (1974)[18]described the usefulness of tibial plateau view to determine the amount of depression in fracture fragment.

David Schulak and Donald Gunn (1975) did 13 studies including 599 patients with result of 70 % acceptability. They stated that torn ligaments of meniscus should be repaired in all fractures for better outcome. Burei C, Bartzke , J.Coldeway and E. Muggler (1979)[1] did their study on 278 patient with tibial plateau fractures treated by both surgical and non-surgical methods. Results were in favour of surgical treatment with depression. Schatzker J, McBroom R, Bruce D (Toronto experience 1968-75)[24] described detailed classification of proximal tibia fractures which was informative and helpful in surgical planning as well as it had prognostic values. They divided these fractures in 6 types. Graham Apley (1979)[32] studied different ways to treat the proximal tibia fractures and concluded that skeletal traction and early mobilization is beneficial in good outcome. Tillman M. Moore (1981)[17] described a new classification of fractures which is more informative in association of instability and soft tissue injuries.

Caspari RB, Hutton PM, Whipple TL, Meyers JF (1985)[5] were the first to describe the role of arthroscopy in such fractures. It was determined that acute fractures and associated soft tissue injuries can be better addressed, and based on direct arthroscopic observation, selected fractures can be reduced and stabilized. Blokker , C. H. R Orabeck and R.B. Bourne1984)[2]after studying 60 patients stated the importance of anatomical reduction and maintenance of articular reduction. Steven Gausewitz and Mason Hohl (1986)[27] described the importance of early mobilization in outcome of treated fractures to prevent post-operative stiffness in the joint. Moore TM1, Patzakis MJ, Harvey JP (1987)[19] presented results of study done on 988 patients which were treated surgically and non-surgically. Results showed that anatomic reduction of plateau fractures, in addition to early motion, is a major factor contributing to successful management of this potentially disabling injury.

Fernandez DL1.(1988) [7] recommended the anterior approach with osteotomy of tibial tubercle in treatment of patients who have a severely displaced bicondylar fracture of proximal end of the tibia. Mallik AR1, Covall DJ, Whitelaw GP (1992)[15]used a technique of indirect reduction followed by application of a hybrid circular external fixator, noting a stability similar to that of an open reduction and internal fixation but with fewer complications. Stamer DT1, Schenk R, Staggers B, Aurori K, Aurori B, Behrens (1994)[23]studied bicondylar tibial fracture in 22 patient treated with hybrid external fixator and concluded that this method provides good stabilization and allows early range of motion for complex tibial plateau fractures where extensive dissection and internal fixation is contraindicated due to traumatized soft tissue, osteopenia, and fracture comminution.

Watson JT1 (1994)[25] emphasised the importance of treating soft tissue injury and its associated outcome. He concluded that either internal or external fixation techniques were used, appropriate management of soft tissues is a prime factor in successful management of these injuries to the knee. Young MJ1, Barrack RL (1994)[26] in their study on 45 patients found that the patients with comminuted tibial plateau fractures requiring either two buttress plates or a single plate with additional interfragmentary lag screws would probably be better managed by either non-operative treatment or limited internal fixation. Honkonen SE (1995)[12] studied causative factor of the secondary osteoarthritis in 131 patients and concluded that valgus tilt is more favourable with preserved meniscus while varus tilt and absence of meniscus were unfavourable factors. Buchko GM(1996)[3] used arthroscopic methods to achieve reduction and fixation with limited internal or external devices . Comminuted bicondylar fractures were not considered as good prospects for arthroscopic reduction.

Barei DP(2006)[1] in their study on 83 patients with bicondylar fracture of proximal tibia concluded that medial and lateral plate stabilization of comminuted bicondylar tibial plateau fractures through medial and lateral surgical approaches is a useful treatment method. Oh CW et al (2006)[20] in his study on 23 patients concluded that double plating using minimally invasive percutaneous technique can provide favourable results in the treatment of proximal tibial fractures. M. R. Bansal (2009)[28] studied the use of Bovine cancellous xenograft in the treatment of tibial plateau fractures in elderly patients. No patient had wound infection and all had excellent incorporation of the xenograft with union. Luo et al (2010)[14] proposed a newer classification of fractures for proximal tibia, which is based on CT SCAN findings. All fractures were classified as a "three-column fracture," which means at least one separate fragment was found in lateral, medial, and posterior columns in the proximal tibia (Schatzker classification Types V and VI).

Three-column fixation is a new fixation concept in treating complex tibial plateau fractures, which is especially useful for multiplanar fractures involving the posterior column. The combination of posterior and anterior-lateral approaches is a safe and effective way to have direct reduction and satisfactory fixation for such difficult tibial plateau fractures. Matthias Krause (2016) [29] proposed a '10 segment' classification of proximal tibia to help in making decision for better surgical approach and to guide the reduction. H. Hoekstra (2017) [9] proposed a revised 3-column classification for surgical planning of extended lateral tibial plateau fractures. It provides better surgical organization for posterolateral fracture fragments.

II. Materials And Methods

This is a retrospective study conducted in GOA MEDICAL COLLEGE AND HOSPITAL, BAMBOLIM after approval from the ethical committee board members. Average age of patients was 32.8 years. Oldest patient was 71 years and youngest patient was 20 years old. All the patients with bicondylar fracture treated with dual plating from 1st AUGUST 2011 until 1ST AUGUST 2016 were studied and followed up till July 2017. Data was obtained from the Medical record department, indoor ward records, OPD registers and Operation theatre records.

Inclusion criteria of the study were

- Bicondylar tibia fractures treated with dual plating.
- No previous involvement of ipsilateral leg in surgery.
- No previous arthritis or any other joint abnormality.

The hospital data sheet included brief history of the incident, mechanism of injury, delay in surgery and operative notes. Preoperative conditions, preoperative x-rays and post-operative x-rays with details of wound condition , period of immobilization , period of non-weight bearing , status of range of motion with each follow up was obtained though their follow-up outdoor patient medical notes. The data records were specifically searched for intraoperative and postoperative complications. The patients were contacted on phone and/or conventional mail. All the patients were informed of the study and consent to participate was taken. Total 119 patients were recorded with Shatzker's type V and type VI fractures, 95 patients were treated with dual plating. 16 patients were not included in the study because they could not comply with follow up protocol while 11 patients were excluded as they lost follow-up in between.

Total 68 patients were included in the study. The functional outcome was evaluated according to Rasmussen scoring system (Rasmussen, 1973) [22] Mal-reduction of the articular surface was defined as an intra-articular step-off of at least 2 mm measured on scaled radiographs. Alignment of the proximal tibia was determined by measuring the tibial plateau angle (the medial angle between the tangential line and anatomic axial of the tibia) on anteroposterior radiographs and the posterior slope angle (the angle between the tangential line of medial plateau and the perpendicular line of the anterior tibial cortex) on lateral radiographs. Tibial plateau angle more than 90° or less than 80° or posterior slope angle equal or more than 15° or equal or less than−5° was considered indicative of mal alignment.

Secondary loss of reduction was defined as an increase of 2 mm intra-articular step-off. Secondary loss of alignment was defined as an increase of 3° mal alignment when compared with the first postoperative radiograph. Bony union was defined radio-graphically by the treating surgeon as 3 or more cortical unions during the follow-up period. Non-union was defined as no evidence of healing after 9 months. All patients were given preoperative antibiotics (1.5 gm cefuroxime intravenous) as per the institution protocol after testing for any allergic reaction. The operative procedures were performed in a standard operating room under regional or general anaesthesia and tourniquet control. The fractures were approached through anterolateral, posteromedial, medial and lateral side depending upon the fracture configuration.

MATERIALS:- Material that were used in fixation of Shatzker's type V and type VI fractures are-

- Proximal tibia locking plate
- Medial buttress locking plate.
- T-buttress plate.
- 6.5 mm cancellous screws (plain and locking)
- 4.5 mm locking screw
- 3.5 mm cortical and locking screw.
- Bone graft (+/-)

III. Observation And Results

***AGE*:-** Incidence of the fracture pattern in the age group are needed for the evaluation of the outcome in fractures treated with dual plating, as they pose a difference in the response to postoperative rehabilitation which then directly affects the post- operative outcome. Type V and VI tibial plateau fractures are more common in the age group of young active and productive population who are more involved in outdoor activities. Response of

this young age group to the fixation is better due to greater ability of osteogenesis in comparison to the older age group. The following Table 1 and figure 1 indicates the incidence of operated fractures with dual plating among different age groups.

Age in years	Percentage
<20 years	5%
20-29	44%
30-39	25%
40-49	12%
50-59	10%
>60	4%

Table 1

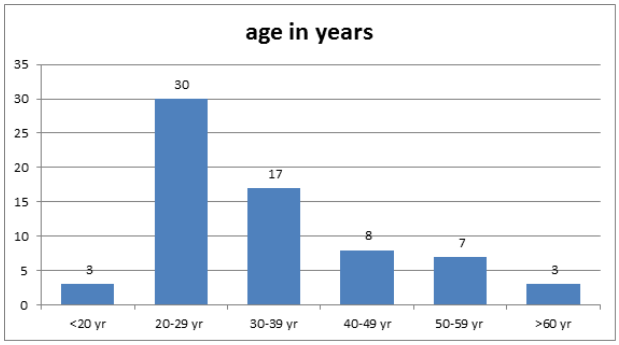

Fig 1

SEX:- Outcome of the tibial plateau fracture is fairly affected by the gender of the patient which attributes to the fact that many of the young male patient have more muscle mass, strong ligaments and greater ability to comply with the post-operative rehabilitation protocol.
Following table 2 shows the relation of fractures treated with dual plating with the gender of the patients.

Gender	No. of cases	Percentage
Male	54	79%
Female	14	21%
TOTAL	68	

Table 2

Majority of the fractures were involved in males compared to females.
OCCUPATION:- The occupation which involves more traveling from one place to another were more likely to be related in high energy injuries. In our study we found greater percentage of the patients were students, drivers and office workers who had to travel every day.

Occupation	No. of cases	Percentage
Student	22	32%
Office workers	15	22%
Drivers	24	35%
Housewives	4	6%
Farmers	3	5%
TOTAL	68	

Table 3

LATERALITY OF FRACTURE:- In our study there was a higher incidence of fractures on right leg compared to left.

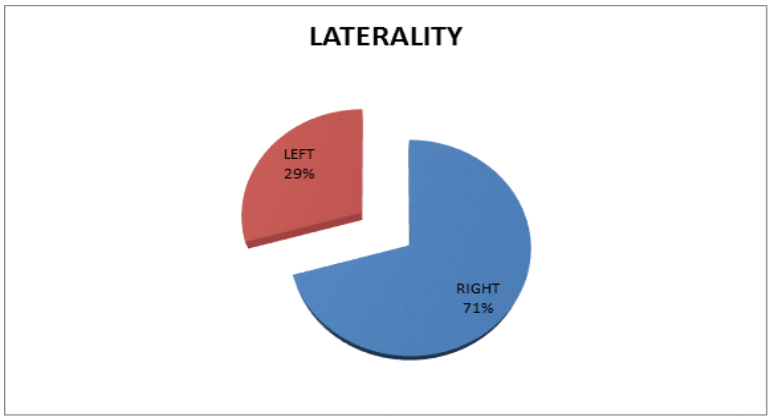

Fig 2

TYPE OF FRACTURE:- Incidences of type V fractures treated with dual plating were more than the type VI fractures**.**

TYPE	No. of cases	Percentage
Type V	40	59%
Type VI	28	41%
TOTAL	68	

Table 4

USE OF BONE GRAFT:- Shatzker's type V and type VI fracture were normally associated with more comminution and depression due to collapse of the cancellous part of condyles. To fill the gap created due to collapse use of bone graft is common in such type of fractures. In our study three fourth of the fractures treated with dual plating were done with the use of bone graft.

BONE GRAFT	No. of cases	Percentage
YES	50	75%
NO	18	25%
TOTAL	68	

Table 5

PERIOD OF IMMOBILISATION:- One of the most important factors that was found to influence the outcome of these fractures was the period of immobilization. In our study majority of the treated patients were mobilized within first week of the surgery as soon as the patient started tolerating the pain. Mobilization in some patients was delayed because of their intolerance to pain or delayed follow up.

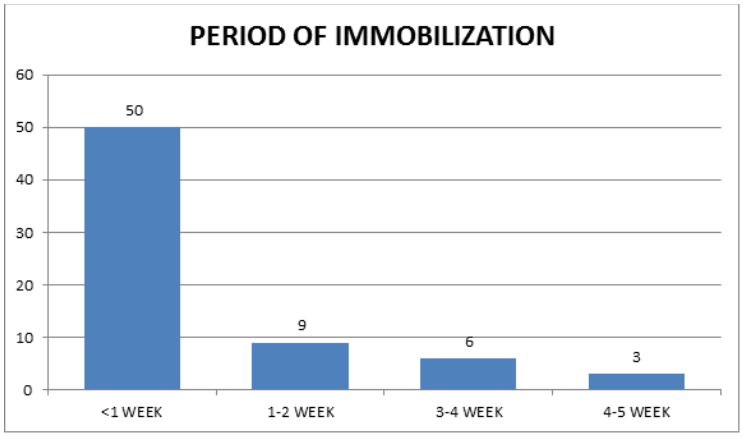

Fig 3

ASSOCIATED INJURIES:- Associated injuries along with the tibial plateau fractures affect the outcome due to delay in immobilization, infection, and relatively poor compliance to the post-op rehabilitation.

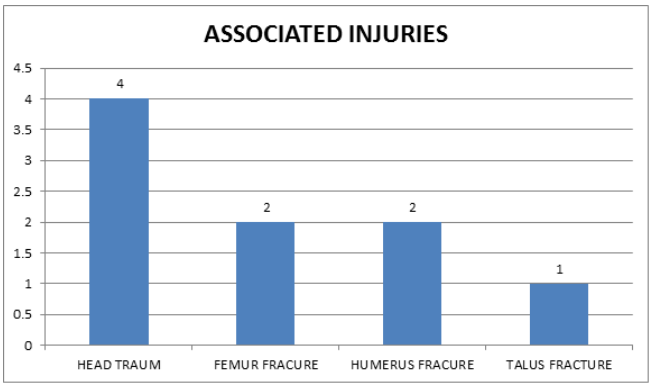

Fig 4

Evaluation and Grading of the obtained results

(CLINICAL SCORE) are according to following criteria-

Range of flexion :-

- >130 degree
- 110 – 129 degree
- 90 -109 degree
- <90 degree
- ***Extension leg :–***

1 .none
2. 1 – 5 degree
3. 6 – 10 degree
4. >10 degree

- ***Thigh atrophy:-***
- None
- >0 to 1 cms
- >1 to 3 cms
- > 3 cms
- ***Stability :-***
- Normal
- Mediolateral -stable in extension, 5-10 degree instability in 30 degree flexion
  Anteroposterior – grade I instability (lachman test)
- Medio-lateral – up to 10 degree instability in extension
  Antero-posterior – grade II instability (lachman)
- Instability- >10 degree in medio-lateral plane

Grade III instability in antero-posterior plane.

[1- EXCELLENT , 2- GOOD , 3- FAIR , 4- POOR]

Evaluation and grading of the obtained results

(*FUNCTIONAL SCORE* **)** are according to following criteria-

***WALK* :-**

- Normal
- Slight limping
- Sever limping or use of stick
- Not able to walk (wheelchair)
- ***STAIR CLIMBING:-***
- Normal
- Impaired
- One stair at a time
- Unable to climb stairs
- ***SQUATTING :-***
- Normal
- Impaired
- <90 degree

- Unable to squat
- ***JUMPING / HOPPING:-***
- Normal
- Impaired
- can jump only with the use of normal leg
- unable to jump

[*1- EXCELLENT , 2- GOOD , 3- FAIR , 4- POOR*]

CLINICAL RESULTS OF OUTCOME IN TABLE 6

Results	Percentage
Excellent	63%
Good	28%
Fair	7%
Poor	2%

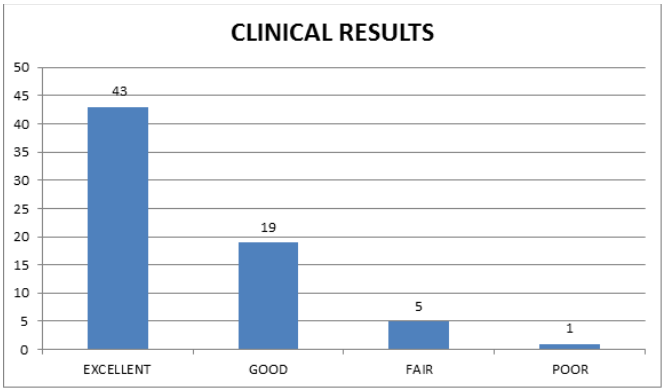

Fig 5

Out of 68 cases treated with dual plating 63 % of the patients showed excellent outcome , 28%. showed good outcome and 7 % revealed fair outcome while 2 % showed outcome to be poor both clinically and functionally. Fair outcome was found mainly in patients with comminuted fracture, delayed mobilization or associated injuries. Poor outcome was found to be higher in those who had associated ipsilateral comminuted supracondylar fracture.

ASSOCIATION OF THE OUTCOME IN TYPE OF THE FRACTURE:

Type of fracture	RESULTS	Total Cases
TYPE V	Excellent-28 Good –11 Fair- 1 Poor- 0	40
TYPE VI	Excellent- 15 Good – 8 Fair- 4 Poor- 1	28
TOTAL		68

Above results of the outcome with type V and type VI fractures treated with dual plating clearly depict that type V fractures have better prognosis in comparison to type VI.

IV. Discussion

Tibial plateau fractures especially type V and type VI pose a challenge to orthopaedic surgeons for being very complex, as they are associated with significant amount of comminution, severe soft tissue and ligament injuries, and associated other long bony injuries.

In a country like India, it is commonly observed that only the male person is the breadwinner of the family, while others are dependent on him. During such situations if the wage earner gets injured then there is tremendous pressure on the family. Hence it not only affects the man himself but the entire family. So the aim towards treatment of these fracture are **'Anatomical reduction, stable fixation and early mobilization '.**

68 cases of Shatzker's type V and type VI treated with dual plating were studied and end results of this study are summarized below.

Features those impact the outcome of treated fractures are as follow –

- Age of the patient
- Sex distribution
- Occupation
- Laterality of the fracture
- Type of the fracture (V / VI)
- Use of bone graft
- Immobilization period
- Associated injuries.

In our study, individuals in between 20-49 years are the ones who have maximum incidence of these high energy fractures. **Boume** in **1981** has also presented with similar results with 74 % of the patients in the age group between 15-55 years, whereas 79 % of the patients present in the age group of 20-49 years. Our study also correlates well with the results of the study conducted by Seppo in **1993** on 130 patients where maximum patients belong to middle age group 30-49 years. While study done by **Vasanand *et al*(2013)** [54] found 75 % patient were in age group 30-50 years.

In our study 79% of the patients were males. In an Indian setup this data can be attributed to the fact that the males are more involved in outdoor works, driving and sports while most females are involved in house hold work. This correlates well with the study done by **Vasanand *et al* (2013)** [54] who found 90 % of the patients were male and **Wu *at al*. (2015)** [55] found 75 % male prevalence in their studies.

Relation with occupation also follows the same as greater portion (93 %)of the fractures were involved among those associated with more outdoor activities as travelling to work, students, and drivers. While incidence was less common amongst those who would engage less in such activities e.g. farmers and house wives (7 %). Besides motor vehicular accidents these injuries were also found to result from a fall from height and less common with trivial fall.

Prevalence in type V fractures 59 % and type VI 41 %. **Prasad *et al*** [56]reported 50-50 % involvement of both types of the fractures. **Wu *et al* (2015)**[55] found 55 % prevalence of type V fractures.

In our study we found that 74 % patients were mobilized within first week of surgery as the principle of anatomical reduction, stable fixation and early mobilization was followed. 13 % patients were mobilized in 2nd week while rest 13 % were mobilized in 3rd to 5th week because of associated injuries. **Vasanand *et al*** in their study of 32 patients mobilized 24 patients within 10 days.

Benefits of early mobilization gives better results in terms of good range of motion, less stiffness, and quick articular healing. However, these benefits have to be balanced against complications which can be associated with early loss of reduction in severely comminuted fractures, extensive internal soft tissue insult, associated ligament injuries and other associated fractures involving ipsilateral limb. In these cases, giving significant amount of time for soft tissue healing may benefit to reduce the surgical wound related problems as well as help in better compliance to the post-operative rehabilitation programme.

Shatzker, Robert mc broom [24] ,magonhobi and steven , gausewitz (1984)[8] stated that prognosis or outcome results of these fractures can be given with consideration of the amount of displacement, comminution, depression, type of fracture, and quality of post-operative care along with rehabilitation programme. With the good pre op , intra -op and postoperative care, broad spectrum antibiotic prophylaxis there was found to be no incidence of infection among closed fractures. However, 2 cases were found to have post-op infection and these both were type 1 compound fractures. Superficial wound complications was noted in 3 patients associated with poor skin condition due to fracture blisters, who were treated and hence did not affect the outcome. Most of bicondylar fractures are known to be associated with significant internal soft tissue insult which appear in the form of swelling and fracture blisters. Therefore, all such fractures were operated 2 or 3 days after injuries. Duration of time between injury and the surgery varied from days to weeks in presence of fracture blisters as surgery with persistent swelling may complicate the closure of the fascia. In our study there was only 1 patient who suffered from compartment syndrome in early post op period owing to preoperative swelling which resulted in tight closure. Emergency release was done and with delayed secondary closure along with flap surgery, patient recovered with good results.

Such dangerous complications can be avoided by careful preoperative evaluation of the patient and proper planning.

Normal or slight valgus alignment of the tibial plateau with intact menisci was found to protect against secondary degeneration. On the other hand, medial or lateral tilt of the tibial plateau with a removed meniscus was followed by osteoarthritis in most cases. The severity of articular irregularities correlated poorly with the degenerative process. Associated ligamentous injuries as well as postoperative infection increase the incidence

of secondary degeneration[12]. Most degenerative changes is known to occur in the first 6-8 years from initial injury [57 , 58.] The probability of degenerative changes increased significantly with increase in age. Important factors in preventing early degenerative changes after intraarticular fractures appear to be early restoration of joint congruity, realignment to the normal anatomical axis, joint stability, and early movement [59]. In our study, majority of the patients were in relatively young age group 20-39, which could be the reason for no new osteoarthritic changes found in the series.

In our series we found 63 % excellent results, 28 % good results, 7 % fair and 2% poor results.These results are comparable to various other studies done. **Chang-Wug Oh *et al*** [20] reported excellent results in 21 patients out of 23 patients.

All cases with bicondylar tibial fracture operated with dual plating are included in this study, while some of the bicondylar fractures which were managed with single plate for one plateau and screws for other plateau are not included..

There were 75 % patients treated with use of bone graft (auto grafts) while 25% without use of the primary bone graft. Use of bone graft is necessary in such fractures as they involve significant amount of comminution and depression which need to be elevated to achieve articular congruous reduction. Use of bone grafting in form of autograft or allograft improve the outcome in treated fractures [60, 61, 62.]

V. Conclusion

Fractures of proximal tibia are increasing with the increase in mechanization and increased road traffic in current world today. These fractures are more in men and those who use automobiles frequently for their outdoor ventures. Skin should be healthy to withstand the stress of dual incision and free from any contusion or abrasion as it may affect wound healing. Swelling at fracture site can lead to difficulty in attaining the closure after fixation.

Orientation of fracture fragments can be helpful in deciding the approache and fixation that can prevent unnecessary soft tissue injury. Addressing the associated injuries like ligament, meniscus and their treatment can result in better outcome. Better preoperative planning in selection of approach can minimize the soft tissue injury and unnecessary periosteal stripping. This can also prevent the risk of flap necrosis.

Early mobilization is the key to achieve good outcome.Stable fixation with dual plating with or without use of bone graft to provide support for subchondral area is important in prevention of loss of reduction; union as well allows early mobilization. A congruent and anatomical reduction is an essential key for better outcome in treated proximal tibia fracture, as it helps in nourishment of articular cartilage; facilitate early mobilization and decrease chances of delayed degeneration.

Bibliography

[1]. Barei, D. P., Nork, S. E., Mills, W. J., Coles, C. P., Henley, M. B., & Benirschke, S. K. (2006). Functional outcomes of severe bicondylar tibial plateau fractures treated with dual incisions and medial and lateral plates. *The Journal of Bone and Joint Surgery. American Volume*, *88*(8), 1713–1721. https://doi.org/10.2106/JBJS.E.00907

[2]. Blokker, C. P., Rorabeck, C. H., & Bourne, R. B. (1984). Tibial plateau fractures. An analysis of the results of treatment in 60 patients. *Clinical Orthopaedics and Related Research*, (182), 193–199.

[3]. Buchko, G. M., & Johnson, D. H. (1996). Arthroscopy assisted operative management of tibial plateau fractures. *Clinical Orthopaedics and Related Research*, (332), 29–36.

[4]. Burrows, H. J. (1956). Fractures of the lateral condyle of the tibia. *The Journal of Bone and Joint Surgery. British Volume*, *38–B*(3), 612–613.

[5]. Caspari, R. B., Hutton, P. M., Whipple, T. L., & Meyers, J. F. (1985). The role of arthroscopy in the management of tibial plateau fractures. *Arthroscopy: The Journal of Arthroscopic & Related Surgery: Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *1*(2), 76–82.

[6]. Dias, J. J., Stirling, A. J., Finlay, D. B., & Gregg, P. J. (1987). Computerised axial tomography for tibial plateau fractures. *The Journal of Bone and Joint Surgery. British Volume*, *69*(1), 84–88.

[7]. Fernandez, D. L. (1988). Anterior approach to the knee with osteotomy of the tibial tubercle for bicondylar tibial fractures. *The Journal of Bone and Joint Surgery. American Volume*, *70*(2), 208–219.

[8]. Gausewitz, S., & Hohl, M. (1986). The significance of early motion in the treatment of tibial plateau fractures. *Clinical Orthopaedics and Related Research*, (202), 135–138.

[9]. Hoekstra, H., Kempenaers, K., & Nijs, S. (2017). A revised 3-column classification approach for the surgical planning of extended lateral tibial plateau fractures. *European Journal of Trauma and Emergency Surgery*, *43*(5), 637–643. https://doi.org/10.1007/s00068-016-0696-z

[10]. Hohl, M. (1967). Tibial Condylar Fractures. *JBJS*, *49*(7), 1455.

[11]. Hohl, M., & Luck, J. V. (1956). Fractures of the tibial condyle; a clinical and experimental study. *The Journal of Bone and Joint Surgery. American Volume*, *38–A*(5), 1001–1018.

[12]. Honkonen, S. E. (1995). Degenerative arthritis after tibial plateau fractures. *Journal of Orthopaedic Trauma*, *9*(4), 273–277.

[13]. Lee, H. G. (1957). Osteoplastic reconstruction in severe fractures of the tibial condyles: Utilization of the anterior superior iliac spine. *The American Journal of Surgery*, *94*(6), 940–944. https://doi.org/10.1016/0002-9610(57)90087-9

[14]. Luo, C.-F., Sun, H., Zhang, B., & Zeng, B.-F. (2010). Three-Column Fixation for Complex Tibial Plateau Fractures. *Journal of Orthopaedic Trauma*, *24*(11), 683–692. https://doi.org/10.1097/BOT.0b013e3181d436f3

[15]. Mallik, A. R., Covall, D. J., & Whitelaw, G. P. (1992). Internal versus external fixation of bicondylar tibial plateau fractures. *Orthopaedic Review*, *21*(12), 1433–1436.

[16]. Martin, A. F. (1960). The pathomechanics of the knee joint. I. The medial collateral ligament and lateral tibial plateau fractures. *The Journal of Bone and Joint Surgery. American Volume*, *42–A*, 13–22.
[17]. Moore, T. M. (1981). Fracture--dislocation of the knee. *Clinical Orthopaedics and Related Research*, (156), 128–140.
[18]. Moore, T. M., & Harvey, J. P. J. (1974). Roentgenographic Measurement of Tibial-Plateau Depression Due to Fracture. *JBJS*, *56*(1), 155.
[19]. Moore, T. M., Patzakis, M. J., & Harvey, J. P. (1987). Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. *Journal of Orthopaedic Trauma*, *1*(2), 97–119.
[20]. Oh, C.-W., Oh, J.-K., Kyung, H.-S., Jeon, I.-H., Park, B.-C., Min, W.-K., & Kim, P.-T. (2006). Double plating of unstable proximal tibial fractures using minimally invasive percutaneous osteosynthesis technique. *Acta Orthopaedica*, *77*(3), 524–530. https://doi.org/10.1080/17453670610012548
[21]. Palmer, I. (1951). Fractures of the Upper End of the Tibia. *Bone & Joint Journal*, *33–B*(2), 160–166.
[22]. Rasmussen, P. S. (1973). Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment. *The Journal of Bone and Joint Surgery. American Volume*, *55*(7), 1331–1350.
[23]. Stamer, D. T., Schenk, R., Staggers, B., Aurori, K., Aurori, B., & Behrens, F. F. (1994). Bicondylar tibial plateau fractures treated with a hybrid ring external fixator: a preliminary study. *Journal of Orthopaedic Trauma*, *8*(6), 455–461.
[24]. The tibial plateau fracture. The Toronto experience 1968--1975. - PubMed - NCBI. (n.d.). Retrieved October 15, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/445923
[25]. Watson, J. T. (1994). High-energy fractures of the tibial plateau. *The Orthopedic Clinics of North America*, *25*(4), 723–752.
[26]. Young, M. J., & Barrack, R. L. (1994). Complications of internal fixation of tibial plateau fractures. *Orthopaedic Review*, *23*(2), 149–154.
[27]. Gausewitz S, Hohl M. The significance of early motion in the treatment of tibial plateau fractures. Clin Orthop. 1986 Jan;(202):135–8.
[28]. Bansal, M.R., Bhagat, S.B. & Shukla, D.D. International Orthopaedics (SICOT) (2009) 33: 779. https://doi.org/10.1007/s00264-008-0526-
[29]. Krause, M., Preiss, A., Müller, G., Madert, J., Fehske, K., Neumann, M. V., … Frosch, K.-H. (2016). Intra-articular tibial plateau fracture characteristics according to the "Ten segment classification." *Injury*, *47*(11), 2551–2557. https://doi.org/10.1016/j.injury.2016.09.014
[30]. Apley G., 1956 "Fractures of the lateral tibial condyle treated by skeletal traction and early mobilization" , *J. Bone Joint Surg*, 38B: 699
[31]. Barr J.S., 1940 " The treatment of the fractures of tibial condyle", *J.A.M.A.* 115 : 1683
[32]. Graham A., 1979 "Fractures of the tibial plateau", *Ortho Clinic Of North America* ,10(1) : 61-74.
[33]. Cotton F.J. and Berg R., 1929 " Fender fractures of the tibia at the knee", *New England Journal Of Medicine*, 201: 989-995
[34]. Salaria, H., & Atkinson, R. (2008). Anatomic study of the middle genicular artery. Journal of Orthopaedic Surgery (Hong Kong), 16(1), 47–49. https://doi.org/10.1177/230949900801600112
[35]. Gardner, E. (1948). The innervation of the knee joint. The Anatomical Record, 101(1), 109–130. https://doi.org/10.1002/ar.1091010111
[36]. Chatra, P. S. (2012). Bursae around the knee joints. The Indian Journal of Radiology & Imaging, 22(1), 27–30. https://doi.org/10.4103/0971-3026.95400
[37]. Shim, S. S., & Leung, G. (1986). Blood supply of the knee joint. A microangiographic study in children and adults. Clinical Orthopaedics and Related Research, (208), 119–125.
[38]. Warren, L. F., & Marshall, J. L. (1979). The supporting structures and layers on the medial side of the knee: an anatomical analysis. The Journal of Bone and Joint Surgery. American Volume, 61(1), 56–62.
[39]. Merican, A. M., & Amis, A. A. (2008). Anatomy of the lateral retinaculum of the knee. The Journal of Bone and Joint Surgery. British Volume, 90(4), 527–534. https://doi.org/10.1302/0301-620X.90B4.20085
[40]. (Moglo & Shirazi-Adl, 2005) Moglo, K. E., & Shirazi-Adl, A. (2005). Cruciate coupling and screw-home mechanism in passive knee joint during extension–flexion. Journal of Biomechanics, 38(5), 1075–1083. https://doi.org/10.1016/j.jbiomech.2004.05.033
[41]. Sarmiento, A., Kinman, P. B., & Latta, L. L. (1979). Fractures of the Proximal Tibia and Tibial Condyles: A Clinical and Laboratory Comparative Study. Clinical Orthopaedics and Related Research, 145, 136.
[42]. Schatzker, J. (1974). Compression in the surgical treatment of fractures of the tibia. Clinical Orthopaedics and Related Research, (105), 220–239.
[43]. CanaleTS. Tibial plateau fracture. In: Canale ST, ed. Campbell's operative orthopaedics. 10th ed. Philadelphia, Pa: Mosby, 2006; 3146–3161.
[44]. HohlM. Fractures of the proximal tibia. In: Rock-wood CA, Green DP, Bucholz RW, eds. Fractures in adults. Philadelphia, Pa: Lippincott, 1991; 1725–1761.
[45]. HohlM, Moore TM. Articular fractures of proximal tibia. In: Evarts CM, ed. Surgery of the musculoskeletal system. Vol 4, 2nd ed. New York, NY: Churchill Livingstone, 1990; 3471–3497.
[46]. Müller, M. E., Koch, P., Nazarian, S., & Schatzker, J. (1990). Tibia/Fibula = 4. In The Comprehensive Classification of Fractures of Long Bones (pp. 148–191). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-61261-9_7
[47]. Kandemir U, Maclean J. Surgical approaches for tibial plateau fractures. J Knee Surg. 2014 Feb;27(1):21–9.
[48]. Fernandez DL. Anterior approach to the knee with osteotomy of the tibial tubercle for bicondylar tibial fractures. JBJS [Internet]. 1988;70(2).
[49]. Solomon LB, Stevenson AW, Baird RPV, Pohl AP. Posterolateral Transfibular Approach to Tibial Plateau Fractures: Technique, Results, and Rationale. J Orthop Trauma [Internet]. 2010;24(8).
[50]. Frosch K-H, Balcarek P, Walde T, Michael Stürmer K. A New Posterolateral Approach Without Fibula Osteotomy for the Treatment of Tibial Plateau Fractures. Vol. 24. 2010. 515 p.
[51]. Lobenhoffer P, Gerich T, Bertram T, Lattermann C, Pohlemann T, Tscheme H. [Particular posteromedial and posterolateral approaches for the treatment of tibial head fractures]. Unfallchirurg. 1997 Dec;100(12):957–67.
[52]. Galla M, Riemer C, Lobenhoffer P. [Direct posterior approach for the treatment of posteromedial tibial head fractures]. Oper Orthopadie Traumatol. 2009 Mar;21(1):51–64.
[53]. Aurich M, Koenig V, Hofmann G. Comminuted intraarticular fractures of the tibial plateau lead to posttraumatic osteoarthritis of the knee: Current treatment review. Asian J Surg [Internet]. 2017 Jan 26
[54]. Vasanad GH, Antin SM, Akkimaradi RC, Policepatil P, Naikawadi G. "Surgical Management of Tibial Plateau Fractures – A Clinical Study." J Clin Diagn Res JCDR. 2013 Dec;7(12):3128–30.

[55]. Wu D, Reng G, Shrivastava A, Yu Y, Zhang Y, Peng C. A useful surgical strategy for proximal tibial fractures (AO/OTA type 41-C) with diaphyseal involvement. Int J Clin Exp Med. 2015 Aug 15;8(8):13455–63.
[56]. Prasad GT, Kumar TS, Kumar RK, Murthy GK, Sundaram N. Functional outcome of Schatzker type V and VI tibial plateau fractures treated with dual plates. Indian J Orthop. 2013;47(2):188–94.
[57]. Buckwalter JA, Brown TD. Joint injury, repair, and remodeling: roles in post-traumatic osteoarthritis. Clin Orthop. 2004 Jun;(423):7–16.
[58]. Volpin G, Dowd GS, Stein H, Bentley G. Degenerative arthritis after intra-articular fractures of the knee. Long-term results. J Bone Joint Surg Br. 1990 Jul;72(4):634–8.
[59]. 10. McKinley TO, Rudert MJ, Koos DC, Brown TD. Incongruity versus instability in the etiology of posttraumatic arthritis. Clin Orthop. 2004 Jun;(423):44–51.
[60]. BUCHOLZ RW, CARLTON A, HOLMES R. Interporous Hydroxyapatite as a Bone Graft Substitute in Tibial Plateau Fractures. Clin Orthop [Internet]. 1989;240.
[61]. LACHIEWICZ PF, FUNCIK T. Factors Influencing the Results of Open Reduction and Internal Fixation of Tibial Plateau Fractures. Clin Orthop [Internet]. 1990;259.
[62]. Lobenhoffer P, Gerich T, Witte F, Tscherne H. Use of an Injectable Calcium Phosphate Bone Cement in the Treatment of Tibial Plateau Fractures: A Prospective Study of Twenty-Six Cases With Twenty-Month Mean Follow-Up. J Orthop Trauma [Internet]. 2002;16(3).

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