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Original research article

Functional result after open reduction and internal fixation for bicondylar fractures of the tibial plateau: A prospective observational study

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Abstract

Background and Objectives: The purpose of the current study was to evaluate the functional outcome of bicondylar tibial plateau fractures treated by open reduction and internal fixation utilising: Rasmussen's functional grading system and Rasmussen's radiological grading system. Both of these grading systems were developed by Rasmussen.

Methods: The GIMSR Department of Orthopaedics at Visakhapatnam, Andhra Pradesh, conducted a prospective observational study from August 2021 to January 2023. Surveyed were orthopaedic patients with bicondylar tibial plateau fractures. Tibial Plateau fractures were most common in adults, especially urbanites. Thirty bicondylar tibial plateau fractures needed correction. A sample size of 26 is needed to obtain 80% power and 95% accuracy if % of participants have a certain functional outcome. 30 participants were used to adjust for dropouts.

Result: For evaluating each individual who took part in the research project, Rasmussen's functional and radiological grading systems, which he had devised, were applied. Both of the grading methods had a strong correlation (r = 0.888) not only with one another but also with the overall result.

Conclusion: Open reduction and internal fixation of bicondylar tibial plateau fractures will restore articular congruity, enable early motion, minimise post-traumatic OA, and optimise knee function. Regardless of velocity and initial comminution, careful articular reduction and waiting for soft tissue healing yield good functional results. The locking compression plate is stable for tibial plateau fractures, and the locking screw held well even in osteoporotic bones. Malalignment and instability affect function more than joint surface deformity.

Keywords: Bicondylar fracture, tibial plateau, osteoporotic bone, rasmussen radiological findings

Introduction

There are three main weight-bearing joints in the lower extremities, and one of them is the knee. One of the most frequent intraarticular fractures is the proximal tibia. These types of fractures can be classified as either high energy or low energy.

Direct axial compression, typically with a valgus (more common) or varus movement, and indirect shear forces are the most prevalent causes of tibial plateau fractures, which are mainly the result of high-velocity incidents or falls from height. Depression type fractures are more common in elderly patients with osteopaenic bone because subchondral bone is less able to resist axial directed loads. These fractures occur extra-articularly in the proximal tibia and are typically caused by direct bending forces applied to the metadiaphyseal region of the upper leg [1, 2, 3].

Tibial plateau fractures are the most common intra-articular proximal tibia fractures in adults, most commonly affecting those in their third to fifth decades. Tibial plateau fractures span a wide range of severities, from those with straightforward injuries and excellent prognoses following non-operative therapy to those with more complicated fracture patterns. The vocabulary around tibial plateau fractures is still heavily influenced by the Schatzker classification, which described pathoanatomy and indicated therapeutic techniques. Tscherene and Lobenhoffer highlighted the fact that 67 percent of meniscal injuries were pure plateau fractures, whereas 96 percent of cruciate injuries and 85 percent of medical collateral ligament injuries were fracture dislocations [4, 5].

Nonetheless, sports injuries, falls and other less violent trauma are common causes of proximal tibial articular fractures, especially in elderly patients with osteopenia. Neurological and vascular injury, compartment syndrome, deep vein thrombosis, contusion or crush injury to soft tissues, or open wounds

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are all possible complications of high-energy mechanisms that lead to proximal tibial articular fractures. Schulak and Gunn found a correlation between the type and mechanism of force applied to the knee and the resulting fracture type and frequency of collateral ligament injury [6, 7, 8].

The goal of treating displaced fractures is to get a stable, pain-free knee joint with a normal range of motion regulated by well-functioning muscles. This is accomplished by anatomically restoring the articular surfaces, repairing soft tissue damage, and using stiff internal fixation. Tibial plateau fractures are still debatable in terms of treatment. Apley advocated for early motion combined with bone traction. Cast-bracing was strongly recommended by Scotland and Wardlaw. Open reduction with anatomic restoration of the articular surface has been found to be the most effective treatment for tibial plateau fractures, according to recent clinical evaluations by Schatzker *et al*. and Waddell *et al*. [8, 9].

The degree of intra-articular comminution, the existence of a step deformity on the weight-bearing surface, and the degree of residual angulation deformity all influence the treatment outcome. A positive outcome is normally to be expected if the step deformity can be eradicated with correct anatomic reduction and the reduction can be maintained. By contrast, intra-articular comminution with depression is a trickier challenge, as late collapse and deformity due to comminution on the weight-bearing surface sometimes preclude a favourable functional result even if an accurate anatomic reduction is attained. The goal of surgery for a broken tibia is to realign the tibial condyles such that they articulate smoothly with one another, while also preserving the knee's mechanical axis and re-establishing the ligaments that hold the kneecap in place [10, 11].

Clinical research has shown that bones under a rigid conventional plate are thin and a tropic, making them vulnerable to subsequent displacement after the plate has been removed due to inadequate buttressing. Osteosynthesis at a fracture site takes longer because soft tissue and periosteal stripping cut off blood flow to the bone. Hence, MIPO (Minimally Invasive Percutaneous Plate Osteosynthesis) was developed as a novel method of biological fixation (MIPPO). However, traditional plates required precise contouring in order to achieve excellent fixation, and poor fixation was also an issue for patients with osteoporosis [11, 12].

Less invasive stabilising systems have been developed as our understanding of biological fixation improves, thanks to advances in plate technology (LISS). The AO locking compression plate is the result of efforts to merge these two techniques (LCP). As this novel approach has been shown to be effective in treating complicated fractures and osteoporotic bones, we believe it to be technically mature. We evaluated the efficacy of open reduction and internal fixation for patients with bicondylar tibial plateau fractures in a prospective observational analysis [12, 13].

Material and Methods

The Department of Orthopaedics at the GIMSR-Gitam Institute of Medical Sciences and Research in Visakhapatnam, Andhra Pradesh, conducted a prospective observational study between August 2021 and January 2023. Patients with bicondylar tibial plateau fractures, including 26 men and 4 women, who were admitted to the orthopaedics department at GIMSR were surveyed. Tibial Plateau fractures were seen most frequently in adults, most of whom were from urban locations. There were thirty fractures of the tibial plateau's bicondylar area that had to be closed. With 80% power of study and 95% precision, a sample size of 26 would be needed if the proportion of participants having a given category of functional outcome was assumed to be %. It was chosen to include 30 people in the study to allow for attrition due to non-participation.

Inclusion criteria

1. Fractures of the tibial plateau that are closed bicondylar
2. Everyone above the age of 18 is welcome to apply.
3. Surgical candidates

Exclusion criteria

1. Injured people who have gaping wounds
2. Fracture of the femur and patella on the same side
3. Chronically underdeveloped skeletons
4. Individuals who were already limited in their mobility prior to injury
5. Reduced longevity caused by multiple chronic conditions.
6. Incompatible with surgical intervention

Methodolgy

Treatment for 32 closed bicondylar tibial plateau fractures involved a two-stage technique consisting of transarticular external fixator/splint application followed by open reduction and internal fixation a few days later. Only a few patients had emergency open reduction and internal fixation surgery. The follow-up on two patients failed. All cases underwent prospective observation. Consisting of 26 men and 4 women, the average age was 40. (range, 20-61 yrs). Twenty-one cases involved the right knee and nine

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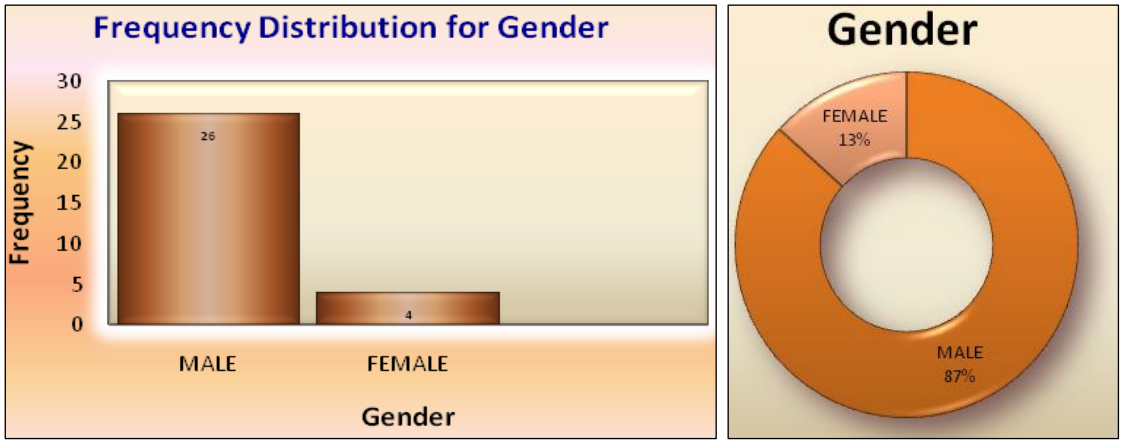
the left. Every single one of their wounds was the result of a car crash.
Patient details were taken, a general physical examination was performed, and a local evaluation of the fractured limb was performed prior to surgery. The emergency department staff immobilised the limb in a slab above the knee. Pre-operative bloodwork was sent out and a thorough physical was conducted. In all patients, radiographs of the proximal leg and knee were taken for pre-operative planning, and the degrees of displacement, depression and agulation were noted. When the fracture pattern or depth of depression remained unclear, CT scan was preserved as a diagnostic alternative [13, 14].
We took the height of the healthy plateau as our baseline to determine the degree of condylar depression. Tibial plateau and femoral condyle widths were measured just below and above the joint line, respectively, to determine the degree of condylar enlargement. Typically, these two dimensions will be the same. Fractures were staged using the schatzker classification system after radiographs were taken. The degree of edoema, the type of fracture and the degree of comminution all played a role in the formulation of the treatment strategy. Our decision to perform a two-stage operation, consisting of a transarticular external fixator application/splint application for the knee joint, followed by open reduction and internal fixation a few days later, was based on these considerations [14, 15].

Result

Windostat, version 9.2 from Indostat Services, was used to analyse the data. Age, gender, mode of injury, kind of fracture, and other factors such as reduction in fixing technique were included in the set of explanatory variables. Outcome variables included the clinical Rasmussen score, the radiological Rasmussen score, and the final degree of knee flexion. All of the variables involved in the explanation and the results were analysed descriptively. Frequencies and percentages were used to represent all of the categorical data. Independent T-test calculations of means, mean differences, and p-values were used to evaluate the strength of the link between explanatory and outcome factors. Appropriate descriptive analysis of additional pertinent parameters was also provided.
Gender distribution: Thirty people in all were used for the statistical study. Males made up 87% of the total, while females represented 13%.

Table 1: Gender Distribution in Study Population (N=30)

Gender	Frequency	Percent
Male	26	87
Female	04	13
Total	30	100



Graph 1: Gender Distribution in Study Population (N=30)

There were nine participants with a left lateralization and twenty-one subjects with a right lateralization. The percentage of those who are more lateral to the left or right was 30% and 70%, respectively.

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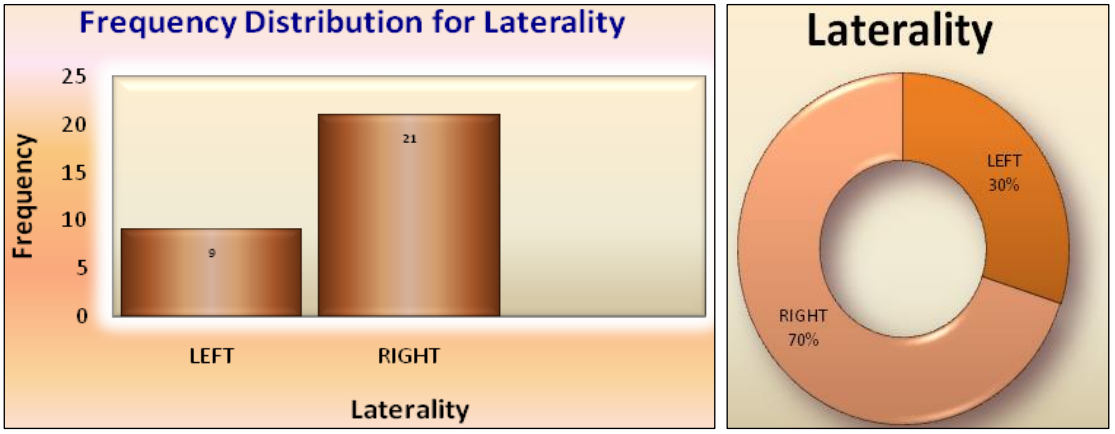
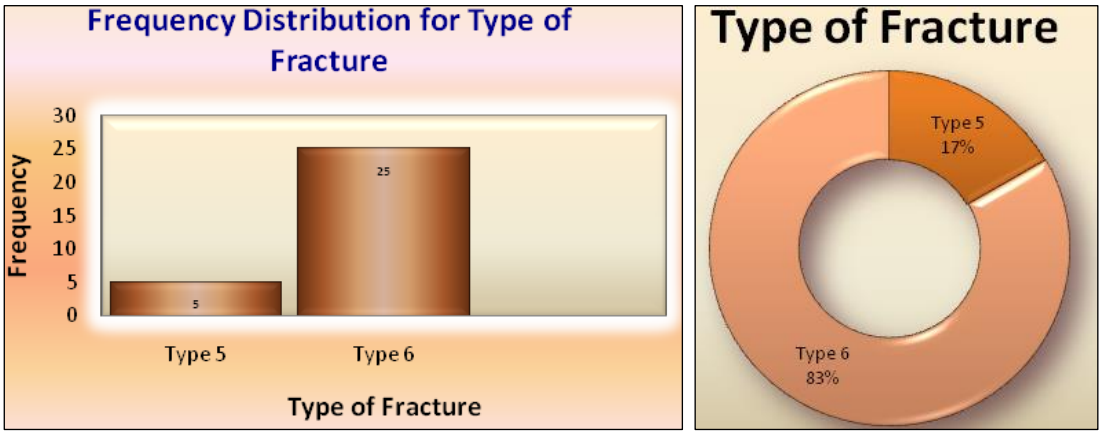


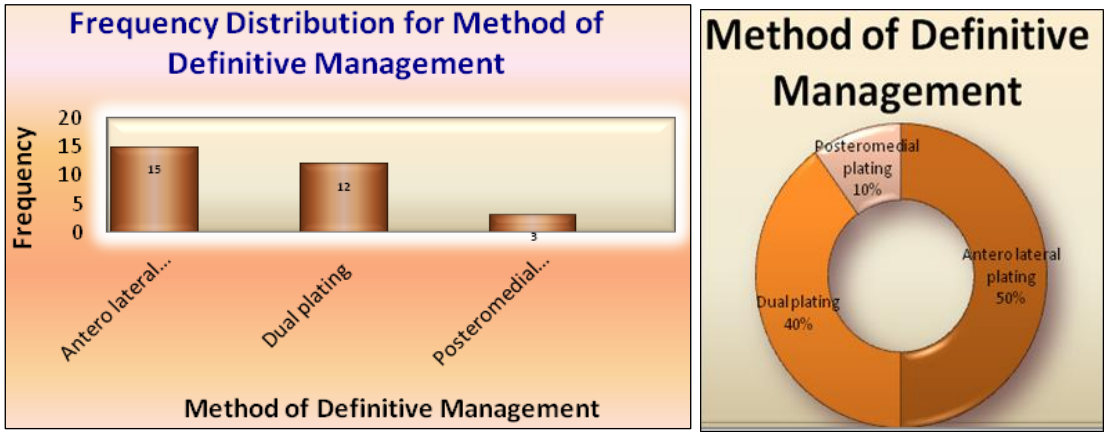
Graph 2: Distribution of laterality in study population

Injury mechanism: Automobile collisions were the cause of injury for all 30 study participants.
Schatzker's type VI pattern was detected in 25 cases, while Schatzker's type V pattern was found in 5 subjects, among the bicondylar tibial plateau fractures. The majority of patients had a type VI fracture (83%), while only 17% had a type V fracture.



Graph 3: Fracture Distribution pattern in study population

Method of definitive management: In 15 subjects ORIF with anterolateral plating was done. In 12 subjects ORIF with dual plating was done and in 3 subjects ORIF with posteromedial plating was done. The proportion of ORIF with anterolateral plating, dual plating, posteromedial plating was 50%, 40% and 10% respectively.



Graph 4: Frequency distribution for method of definitive management in study population

Bone grafting procedures: The majority (21 people) of the 30 people in the study didn't need a bone graft, whereas only 9 people did. Those needing a bone graft made up 30% of the total, whereas the other 70% did not.
The definitive treatment was open reduction and internal fixation (ORIF) with anterolateral plating in 15

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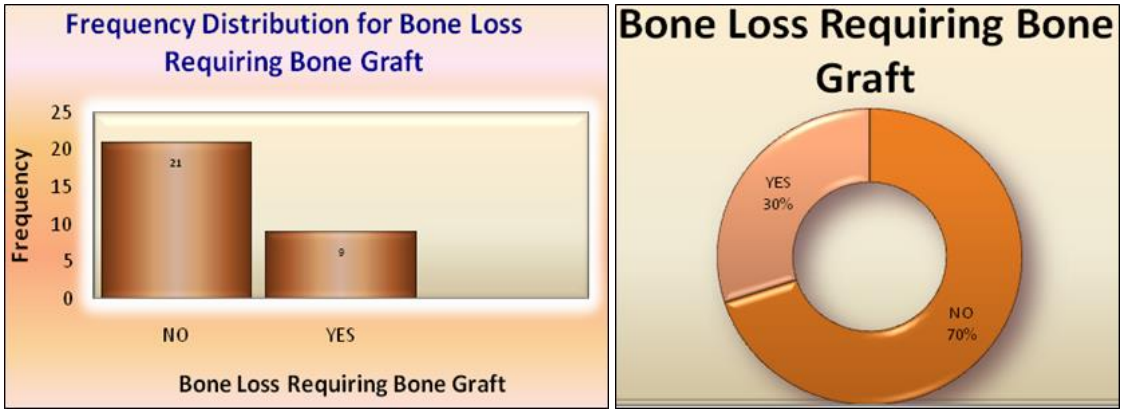
patients. Twelve patients underwent ORIF with dual plating, while three patients underwent ORIF with posteromedial plating. Half of all ORIFs involved anterolateral plating, 40% had dual plating, and 10% involved posteromedial plating.

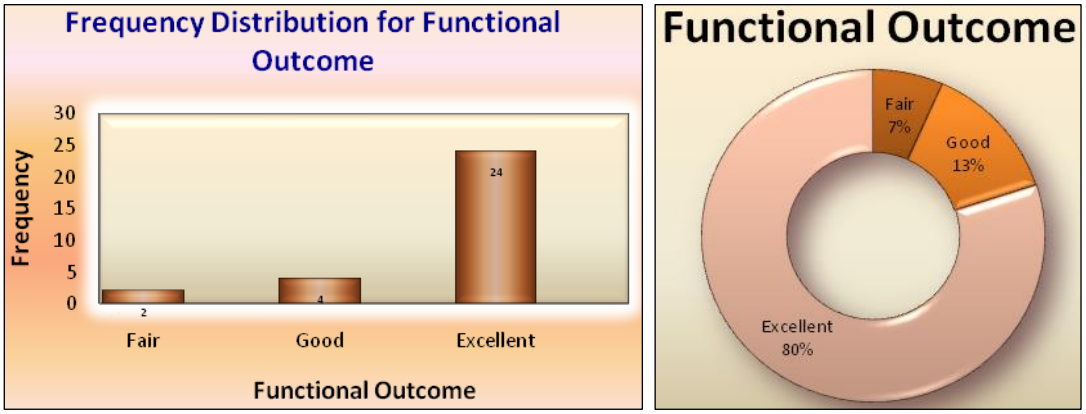


Graph 5: Frequency distribution requiring bone graft in study population

Eighty percent of the patients had a good or outstanding functional result. About 13% of patients had an excellent functional outcome, while only 7% had a fair one.

Table 2: Distribution of Functional Outcome in Study Population (N=30)

Functional Outcome	Frequency	Percent
Excellent	24	80
Good	4	13
Fair	2	07
Total	30	100.0



Graph 6: Distribution of functional outcome in study population

Complications

Collapse of the fracture was a rare complication, affecting just 7% of patients. The vast majority, or 93%, of respondents had no major problems.

Collapse of the fracture was related to metaphyseal comminution and poor patient compliance in these patients who experienced it intra-operatively, despite the fact that the articular surface had been adequately reduced and maintained by adequate fixation.

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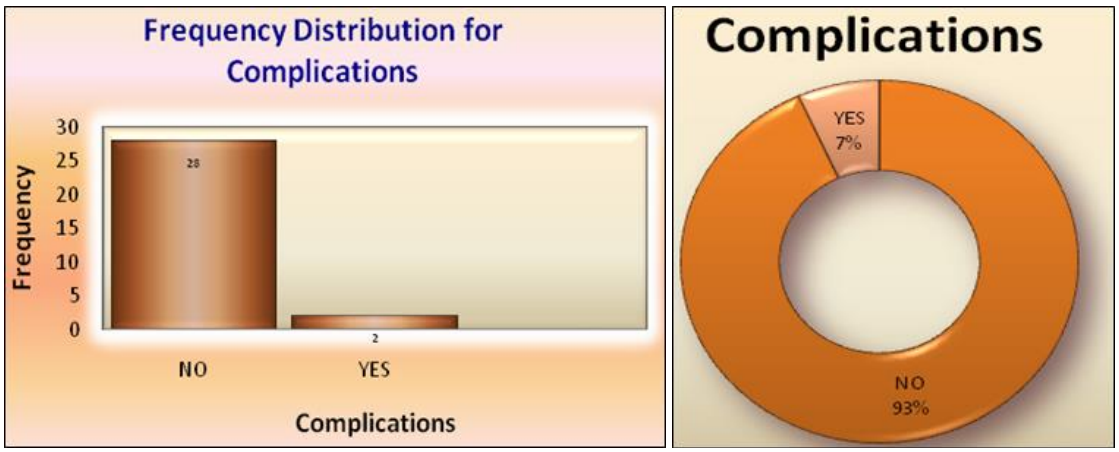

Graph 7: Distribution of Complications in study population

The results of a paired T-test and a Mann Whitney test comparing participants with and without bone grafting on a number of factors showed no statistically significant differences between the two groups.

Table 3: Comparison Between Study Subjects with Bone Graft and Without Bone Graft

Variable	Bone Grafting NO	Std.Err.	Std.Dev.	Bone Grafting YES	Std.Err.	Std.Dev.	T Test	Probability	Mann Whitney	Probability	
Age (years)	39.714	2.683	12.293	40.778 ±	2.712	8.136	0.237	0.814	92.000	0.451	
Gender	1.190	0.088	0.402	1.000 ±	0.000	0.000	1.406	0.171			
Laterality	1.762	0.095	0.436	1.556 ±	0.176	0.527	1.116	0.274	81.000	0.271	
Type of Fracture	5.762	0.095	0.436	6.000 ±	0.000	0.000	1.620	0.116			
Initial Line of Management	1.762	0.095	0.436	1.778 ±	0.147	0.441	0.091	0.928	44.000	0.010	**
Number of Days After Injury for Definitive Management	6.286	1.207	5.533	7.889 ±	2.150	6.451	0.693	0.494	70.000	0.135	
Method of Definitive Management	1.619	0.161	0.740	1.556 ±	0.176	0.527	0.232	0.818	71.000	0.145	
Start Knee Bending And Non-weight Bearing Ambulation (weeks)	2.857	0.360	1.652	2.667 ±	0.333	1.000	0.320	0.751	71.000	0.145	
Start of Protected Weight Bearing (weeks)	8.762	0.810	3.714	8.000 ±	0.577	1.732	0.584	0.564	83.000	0.301	
Start Full Weight Bearing (months)	3.667	0.242	1.111	3.667 ±	0.236	0.707	0.000	1.000	71.000	0.145	
Duration of Follow Up (months)	9.571	0.263	1.207	9.667 ±	0.441	1.323	0.193	0.849	50.000	0.021	*
Final Knee Flexion (degree)	121.429	3.921	17.968	125.556 ±	5.031	15.092	0.602	0.552	70.000	0.135	
Clinical Rasmussen Score	25.571	0.917	4.202	26.889 ±	1.184	3.551	0.821	0.418	58.000	0.049	*
Radiological Rasmussen Score	14.000	0.793	3.633	14.222 ±	0.778	2.333	0.168	0.868	90.000	0.416	
Functional Outcome	2.667	0.144	0.658	2.889 ±	0.111	0.333	0.955	0.348	18.000	0.000	***
Complications	0.095	0.066	0.301	0.000 ±	0.000	0.000	0.940	0.355			

In 21 of the cases, definitive treatment was administered within 7 days of injury, while in 9 of the subjects, treatment was delayed until later due to swelling and the risk of compartment syndrome. Functional outcome was not statistically different between the two groups when compared using the paired T-test and the Mann Whitney test.

We took care of retaining articular congruity by using a joint-spanning external fixator in cases where definitive therapy was postponed due to soft-tissue status and swelling. We proceeded with definitive treatment, which included either dual plating or anterolateral plating, depending on the fracture pattern, once the edoema subsided. We were able to achieve favourable outcomes by maintaining articular congruity initially using a joint spanning external fixator and then providing appropriate therapy following definitive management.

Table 4: Comparison Between Study Subjects Where Definitive Management was Done Before 7 Days and after 7 Days from Time of Injury

Variable	Time to ORIF <7 days	Std.Err.	Std.Dev.	Time to ORIF =>7 days	Std.Err.	Std.Dev.	T Test	Probability	Mann Whitney	Probability	
Age (years)	37.769 ±	3.005	10.833	41.765 ±	2.734	11.272	0.978	0.336	91.000	0.209	
Gender	1.231 ±	0.122	0.439	1.059 ±	0.059	0.243	1.370	0.182	56.000	0.010	**
Laterality	1.615 ±	0.140	0.506	1.765 ±	0.106	0.437	0.866	0.394	51.000	0.006	**
Type of Fracture	5.769 ±	0.122	0.439	5.882 ±	0.081	0.332	0.805	0.428	20.000	0.000	***
Initial Line of Management	2.000 ±	0.000	0.000	1.588 ±	0.123	0.507	2.914	0.007	**		
Method of Definitive Management	1.846 ±	0.222	0.801	1.412 ±	0.123	0.507	1.815	0.080	94.000	0.246	
Bone Loss Requiring Bone Graft	0.231 ±	0.122	0.439	0.353 ±	0.119	0.493	0.705	0.486	39.000	0.001	***
Start Knee Bending And Non-weight Bearing Ambulation (weeks)	2.538 ±	0.332	1.198	3.000 ±	0.402	1.658	0.847	0.404	66.000	0.030	*
Start of Protected Weight Bearing (weeks)	8.154 ±	1.024	3.693	8.824 ±	0.708	2.921	0.555	0.583	79.000	0.094	
Start Full Weight Bearing (months)	3.462 ±	0.243	0.877	3.824 ±	0.261	1.074	0.988	0.332	72.000	0.053	
Duration of Follow Up (months)	9.231 ±	0.231	0.832	9.882 ±	0.342	1.409	1.478	0.150	19.000	0.000	***
Final Knee Flexion (degree)	123.077 ±	5.475	19.742	122.353 ±	3.691	15.219	0.114	0.910	106.000	0.427	
Clinical Rasmussen Score	26.923 ±	1.077	3.883	25.235 ±	0.983	4.055	1.150	0.260	98.000	0.301	
Radiological Rasmussen Score	14.923 ±	0.923	3.328	13.412 ±	0.762	3.144	1.272	0.214	74.000	0.063	
Functional Outcome	2.846 ±	0.154	0.555	2.647 ±	0.147	0.606	0.924	0.363	73.000	0.058	
Complications	0.077 ±	0.077	0.277	0.059 ±	0.059	0.243	0.190	0.850	22.000	0.000	***

Both the functional and radiological grading systems developed by Rasmussen were used to evaluate each participant in the study. Both grading systems were highly connected with one another and with the

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final result (r = 0.888).

Discussion

In this particular investigation, the outcomes of the treatment of thirty different tibial plateau fractures that underwent open reduction and internal fixation were analysed. Patients were examined after a mean of approximately 9.6 months had passed. By utilising Rasmussen's functional and radiological grading system, we ensured that we adhered to standardised reporting and evaluation criteria.

This hospital conducted thirty case studies, and the average age of the patients was forty years old (range 20-61 years). According to the results of Pearson Chi-Square Tests (P=0.288), we discovered that the "age" variable did not exhibit any significant association with the findings in any way. This finding was in line with the findings that Slee, Porter and Wilppula-Bakalim had reported.

In thirty patients, we obtained an acceptable (excellent and good) Rasmussen's functional out come in eighty-seven percent of patients, which is a higher percentage than the study by Biggi F *et al*., who obtained seventy-eight percent of patients with an acceptable functional outcome. In our research, we could not find any correlation between the type of fracture and the functional outcomes. This observation is in line with the findings of Lachiewicz and Funcik, who demonstrated that the type of fracture was not a factor that contributed to less-than-excellent clinical outcomes [16, 17].

Throughout the operation, every effort was made to achieve anatomical reduction of the fracture, despite the high degree of comminution that the bone had already suffered. Blockker came to the conclusion that the appropriateness of the reduction was the single most important element in forecasting the outcome. In his set of tests, bad outcomes were related with a residual step of less than 5 millimetres in the load-bearing area. The step will lead to early osteoarthritis, which can take anywhere from a few years to a decade to develop, but our average follow up was 9.6 months, and the functional outcome was satisfactory in these subjects. This was discovered through the findings of our study, which found that there was no correlation between anatomical grading and functional results [18, 19].

Locking compression plates and locking screws were the kind of implants that were utilised for fracture fixation. According to the findings of this research, the use of stable fixation in the treatment of comminuted or depressed fractures was related with better outcomes than the use of unstable fixation. There was a direct correlation between the stability of the fixation and improved functional performance. They keep the fractures in their proper anatomic alignment using a locking compression plate, and they prevent the loss of reduction when subjected to bending or torsion. This finding was in line with the findings of the research carried out by Hitin and colleagues [19, 20].

We discovered that patients who began knee mobilisation at an earlier stage were able to attain a greater range of motion in their knees. In cases where a congruous articular surface and firm attachment were obtained, early mobility was conceivable. Because of the delay in mobilisation, periarticular scarring developed, and the patient lost the ability to move. Therefore, the findings of this research indicate that there is a clear connection between a congruous articular surface, early physiotherapy, and the consequent range of motion at the knee. Lachiewicz and Funcik found that patients who were immobilised for more than three weeks had a significantly smaller mean range of motion compared to individuals who were immobilised for shorter time periods. According to Rasmussen and Drennan *et al*., the maximum amount of time that the knee should be immobilised for the purpose of recovering normal range of motion is six weeks [20, 21].

It is possible to hypothesise, on the basis of Salter's research, that the slow repair of articular cartilage abnormalities is linked to the development of post-traumatic osteoarthritis. Salter provided evidence that was irrefutable on the significance of motion in the process of neochodrogenesis in experimental animals. After conducting experiments on cadaveric limbs and seeing the results of those experiments, Struben came to the conclusion that early movements including flexion and extension would promote the joint surface to remould to its original shape. Thus, his experimental studies were supported by the concept of Apley, which states that early knee bending exercises caused acceptable outcomes and that skeletal traction associated with early movement, with or without a cast brace, is important in the ultimate outcome of a tibial plateau fracture. Apley also states that early movement with or without a cast brace is important in the ultimate outcome of a tibial plateau fracture [21, 22].

Depending on the fracture patterns, the skin incision may end up being slightly different from the conventional technique. The ability to plan for and ultimately achieve a reduction in the number of individual fractures is considerably aided by a grasp of the mechanisms that cause fractures (for example, axial impaction as opposed to shear or dislocation stress). Because of the complex anatomy of the tibial plateau, Tscherne and Lobenhoffer show that it is essential to achieve optimal restoration of the plateau surface and the axis of the leg in order to prevent post-traumatic osteoarthritis. In all instances with cancellous bone compression, this will typically involve open reduction in conjunction with bone grafting. Techniques such as closed reduction and fixation, pin fixations and other similar procedures do not play a significant role in treating this type of fracture [22, 23].

Our research found that the beginning of full weight bearing occurs on average at 15.71 weeks, which is earlier than the research conducted by Spagnolo R and Pace F, which found that the beginning of full

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weight bearing occurs on average at 16.2 weeks. We discovered that patients who began knee mobilisation at an earlier stage were able to attain a greater range of motion in their knees. In certain situations, early movements were still conceivable despite the achievement of firm fixation. According to Thiruvengita Prasad and colleagues' findings, rigorous fixation makes early knee mobilisation possible [23, 24].

Conclusion

Taking into account the state of the soft tissues at the time of definitive management, open reduction and internal fixation of bicondylar tibial plateau fractures will provide excellent anatomical reduction and stable fixation to restore articular congruity, facilitate early motion, and reduce post-traumatic OA, allowing for optimal knee function. Meticulous articular reduction and waiting surgery for appropriate soft tissue healing allow for satisfactory functional results regardless of velocity of damage and initial comminution.

We observed that the locking screw had an outstanding hold even in the osteoporotic bones, and the locking compression plate is a stable fixation method for tibial plateau fractures. Deformity of the joint surface is less important for functional result than malalignment and instability.

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Conflict of interest: Nil.

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