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A study of functional outcome of management of segmental fracture of tibia

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Abstract
Aim of the Study: To evaluate the Functional and Radiological outcome following various modalities of management of segmental fractures of tibia.
Background: Segmental fracture of tibia is rare accounting for 3-15% of fractures of tibia. It is characterized by distinct fracture at two or more levels creating one or more completely separate intercalary fragments of tibia.
Materials and Methods: The data for this study will be collected from the patient admitted to Rajah Muthiah Medical College and Hospital, Annamalai University, Chidambaram. This study is a prospective and retrospective study.45 cases of segmental tibia surgically treated are followed up for a minimum period of twelve months and functional outcome observed by Johner and wruch's criteria.
Results: In study group 45 cases treated 39 were male and 6 were female. RTA was the most common cause. Right side limb more affected than left side. Common age group affected were 40-60 years. 26 were closed injury and 19 were open injury.32 cases were treated with IMIN nailing, external fixator in 6 cases, MIPO in 5 cases, illizarov in 2 cases. The final outcome based on johner and wruch's criteria is excellent in 75.6%, good in 15.6%, fair in 6.7%, and poor in 2.2%.
Conclusion: The results of our study suggest that if soft-tissue handling and restoration of anatomical alignment are successful in the treatment of challenging segmental tibial fractures, both IMN and MIPO will be good treatment methods. But in reality study/research lack in definitely proving the superiority of one over the other.

Keywords: segmental fracture tibia, intramedullary nailing, mipo, external fixator, ilizarov, johner and wruchs criteria

Introduction
Segmental fracture of tibia cannot be treated by a simple set of rules. By its very location the tibia is prone to frequent injury in this vehicle and industrial era. It is characterized by distinct fracture at two or more levels creating one or more completely separate intercalary fragments of tibia. Assigned AO classification is 42C2. In high velocity injury the segment may be comminuted. Segmental fracture of tibia is rare accounting for 12-15% of fractures of tibia.
Segmental fractures of tibia pose a challenge to operating orthopedic surgeons due to their infrequent presentation, wide zone of tissue injury and increased rate of complication. The perfusion of the intermediate segment is provided through endosteal and periosteal blood supply which sustains increased damage leading to impaired fracture healing with the already precarious blood supply of the intermediary cortical segment. Woll *et al.* [6]. Classified segmental tibia fracture as "an extremely high risk injury" with postoperative complications noted more frequently than in any other category of tibia fracture.
There are various modalities of treatment options available from conservative to internal or external fixation. Realistic assessment of the advantage and the hazards of each method in the circumstances of the management of segmental tibia fracture calls for a high degree of clinical judgement, which is harder to acquire, or to impact, than technical virtuosity in the operating theater. However, there is currently clinical equipoise with no consensus on the best method. This study is an attempt to study the long term results of operative management of segmental tibia fracture treated by Intra medullary nailing or plating or external fixator in a standardized and objective manner. Factors affecting the quality of fixation and hence patients ambulation-Functional Outcome have been analysed. The results have been studied in depth with a view to

outline guidelines for better management of these fractures.

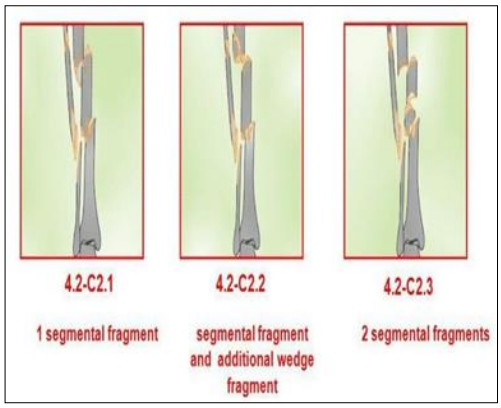


Fig 1: AO classification

Classification-AO classification

The OTA fracture classification defines segmental tibia fractures as complex fractures with an intermediate segmental fragment and thus without contact between the proximal and distal fragments. This classification can be further subdivided into 42-C2.1 with a simple segmental pattern, 42-C2.2 with a segmental pattern as well as wedge fragments, 42-C2.3 with two intermediate segmental fragments, and finally 42-C3.1 with two to three intermediate segmental fragments.

Classification proposed by melis *et al.* in 1981

They divided segmental tibia fractures into four distinct categories based on fragment. Type I: Defines a segmental fragment between the proximal and middle third of diaphysis of tibia Type II: Defines a segmental fragment between the middle and distal third of tibial diaphysis. Type III: Defines a long segmental fragment between the proximal and distal third of tibial diaphysis Type IV: defines a segmental fragment which is entirely contained in middle third of the tibial diaphysis. The open injuries were graded using gustilo Anderson classification system.

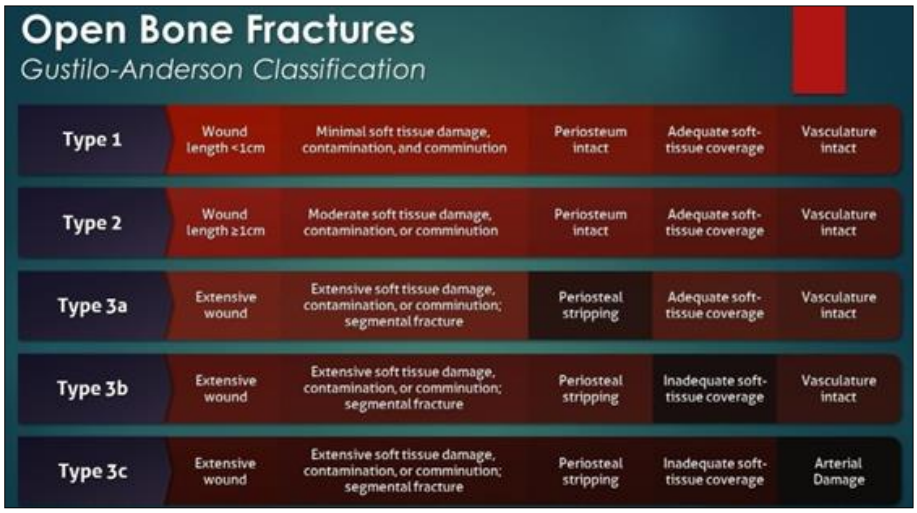


Fig 2: Gustilo – Anderson classification

Criteria	Excellent	Good	Fair	Poor
Nonunion/infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus/valgus	None	2-5^0	6-10^0	>10^0
Ante/Posterior	0-5^0	6-10^0	11-20^0	>20^0
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
Mobility				
Knee	Full	>90 %	90 - 75 %	<75 %
Ankle	Full	>75 %	75-50 %	<50 %
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant limp

Fig 3: Johner and wruch's criteria

Materials and Methods

The data for this study was collected from the patient admitted to Rajah Muthiah Medical College and Hospital, Annamalai University, Chidambaram. This study includes the patients those who fulfilled the inclusion and exclusion criteria from 2017-2020 admitted to Rajah Muthiah Medical College and Hospital. This is prospective and retrospective study. prospective cases were recruited from emergency care OPD from June 2018 to October 2020.the retrospective case are taken from the medical records of Rajah Muthiah Medical College and Hospital, Annamalai university.

Inclusion Criteria

- All segmental fractures of tibia

- Open/closed injury
- Both males and females
- No specific duration of illness

Exclusion Criteria

- Associated vascular injury
- Associated neurological injury
- Pathological fracture
- Severe systemic illness like active cancer elsewhere in body.
- Patients who are not able to give consent.

A sum total of 45 cases of segmental tibia cases reported and studied. Patients were followed up for a minimum period of 1 year. With each follow up functional and radiological evaluation will be done.

All patients were subjected to a detailed history and clinical examination. Clinical examination was performed including general, systemic, neurovascular and local examination of injured part. Depending on nature of injury relevant radiological examination was done. Associated injuries were treated as well.

Plain radiographic evaluation of the fractures was done by anteroposterior (AP) and lateral (Lat) views of the whole tibia including the knee and ankle joints. CT Scan was warranted when articular extension was doubted.

Routine preoperative investigation was followed. Open fractures were immediately irrigated, washed and temporarily immobilized with posterior POP above knee slab or calcaneal pin traction with limb elevation and appropriate analgesics and antibiotics. Patients were operated within 3 to 25 days of hospital admission.

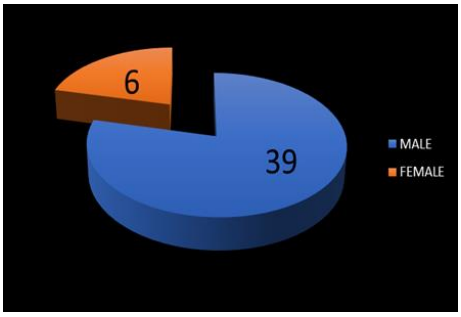
The patients were followed in OPD every 4 weeks for first three visits and thereafter every three months for one year. At each follow up visit patient was assessed both clinically and radiologically. X-ray was taken to note the progress of the union. Clinical examination was done to note the active range of movements at the knee, ankle and foot, time taken for fracture union, residual shortening, deformity and any other complaints. Results were evaluated as Excellent, Good, Fair, and Poor on the basis of Johner R, Wruhs criteria.

Results

The patients who fulfilled the inclusion criteria were chosen for the study. Thorough preoperative planning should be done including proper history taking, clinical examination of associated injuries including neurovascular assessment and complete radiological examination with anteroposterior and lateral views of knee and ankle joint. CT is not taken in all cases ct taken in cases with doubtful intraarticular extension of fractures.

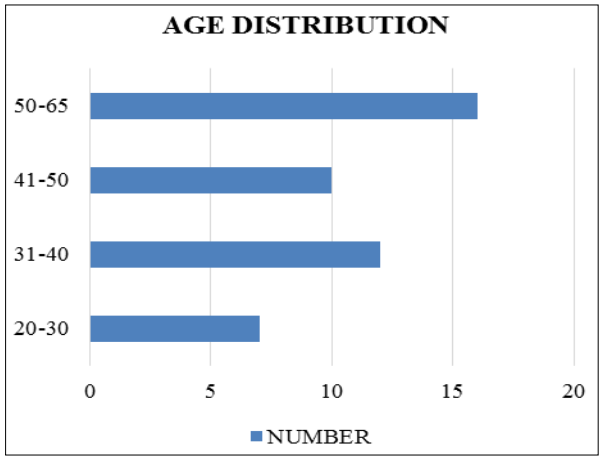
The criteria used for acceptable fracture reduction and alignment : >50% cortical contact; <5-10 deg of varus/valgus angulation when comparing tibial plateau to tibial plafond; <10-15 deg of anterior or posterior bowing on lateral film; not more than 10-15 mm shortening; < 2-3 deg of internal or external rotation.Fracture union was taken as the absence of tenderness at the fracture site during weight bearing with callus bridging at least three cortices on two different views of the fracture radiologically. Functional outcome is studied using johner & wruchs criteria.

A sum total of 45 cases have been followed up for a minimum period of 1yr in this study.

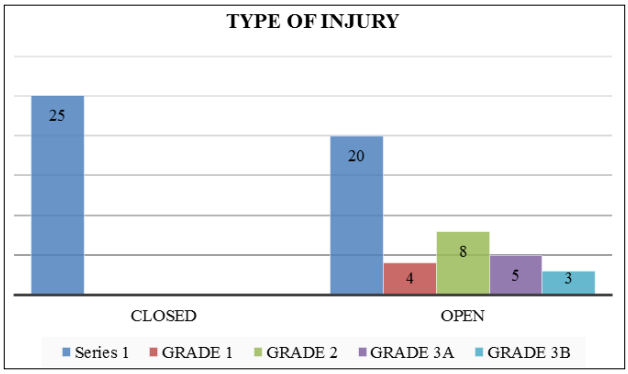


Graph 1: Sex Distribution

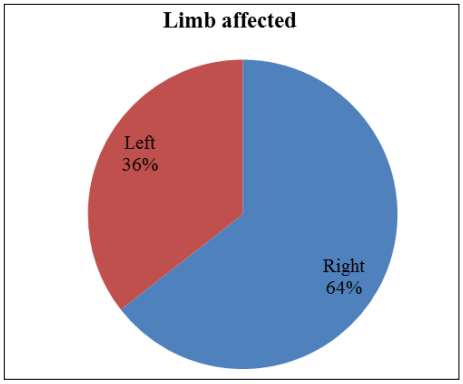
Of the 45 treated 39 were male 6 were female.All the cases have alleged history of road traffic accidents. Most common cause was found to be pedestrian vs vehicle injury. limb affected right side is 29 and left limb is 16.Most common age group affected were 50-65 yrs were 16 people. 25Cases were closed and 20 were open injury.



Graph 2: Age Distribution in Years



Graph 3: Type of Injury



Graph 4: Limb affected

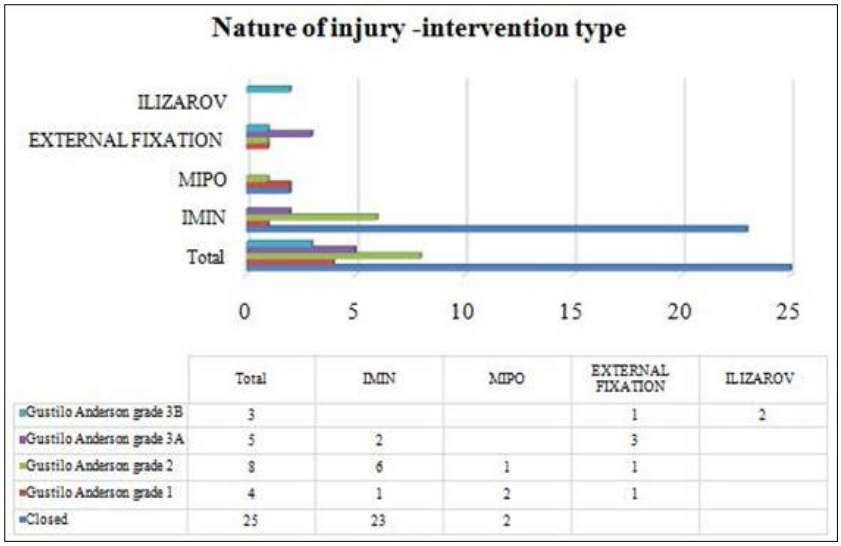
Road traffic accidents was the mode of injury in all the cases. One case had the double segmental tibia fracture, almost all the cases were associated with ipsilateral fibula fracture. Of theses 11 fibula fracture were segmental. None of the cases in study group had fibular fixation. 22 cases were associated with head injury, 11 were associated with clavicle fracture, ipsilateral distal femur and patella fracture in 2 cases, 2 were associated with rib fracture, one had pneumothorax, ipsilateral metatarsal fracture in 2 cases, bilateral both bone fracture in 1 case.

The interval between injury and surgery ranges from 3-20 days, initial immobilisation was with above knee posterior slab in 26 cases and calcaneal pin traction in 19 cases. The mean hospital stay was from 7-30 days, the cases were followed up for minimum of 12 months.

32 cases were treated with imil nailing.11 with expert tibia nail and 21 imil nailing. Two imil cases went for complete radiological and functional union followed up and implant exit done. Most common post operative complication were angulation in 8 cases, angulation less than 10 degrees which was corrected with post operative plaster cast immobilisation and 2 cases which had more than 10 degrees angulation were corrected with augmentation plating, 6 cases reported delayed union after waiting for 12 weeks when abundant callus was not visible in the x-ray and the patient had persistent tenderness over the fracture site. These cases were treated with dynamization and bone grafting. One case treated with ETIN had wound infection and delayed union was followed with nail exit, wound debridement and ilizarov fixation as a secondary procedure followed with Regular dressing, antibiotics coverage and guarded weight bearing. One case with gross butterfly fragment angulation was followed with SS wire cerclage. In our series one patient had superficial wound infection which responded to oral antibiotics and daily dressing. 2 cases were followed up with full union and implant exit was done at 18 months.

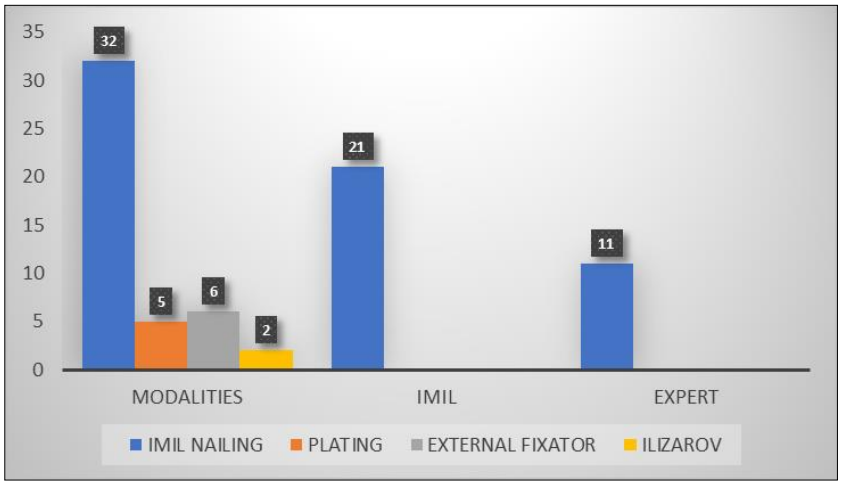
6 Cases were managed with external fixation one went for non union with segmental bone loss treated subsequently by plating with fibular grafting.one case managed by AO external fixator had angulation and delayed union which was treated by angulation correction by exits removal and pop cast and teriparatide application. 3 cases were done with AO external fixator system and 3 done with LRS (Ortho fix) system. All the 6 cases were open injuries and stabilisation with external fixator was taken up as a emergency procedure and done on day1.

5 cases were managed with plating all the plate osteosyntheses cases were done as minimally invasive procedure.and 2 were treated initially with ilizarov fixation.the cases associated with ipsilateral femur and Patella fracture floating knee injury resulted in shortening as a major complication.in this study only compound cases with wound to tend to were chosen for external fixation.



	Total	IMIN	MIPO	EXTERNAL FIXATION	ILIZAROV
Gustilo Anderson grade 3B	3			1	2
Gustilo Anderson grade 3A	5	2		3	
Gustilo Anderson grade 2	8	6	1	1	
Gustilo Anderson grade 1	4	1	2	1	
Closed	25	23	2		

Graph 5: Nature of Injury – Intervention type



Graph 6: Modalities

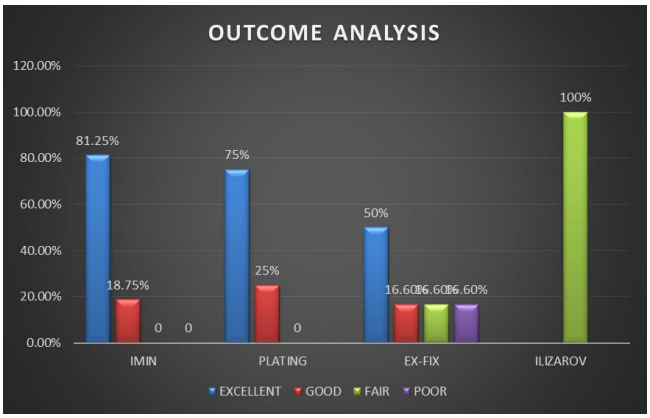
The average mean union time for proximal segment and distal segment fracture were 25.91wks & 28.88 wks in IMILN group, 26.00wks & 26.00 wks plating, 28.67 wks& 32.33 wks in external fixation and 31 wks& 34 wks in ilizarov fixation group. The mean average union time for proximal segment and distal segment fracture tibia were 26.51 weeks and 29.24 weeks.

Table 1: Complication

Complication	IMIN	Plating	External fixator	Ilizarov
Delayed union	6			1
Angulation	8		1	1
Infection	2			1
Pain	2			
Shortening	insignificant	1(5cm)		1(4cm)
Muscle wasting	nil	1		
Non union	nil		1	
Flap necrosis	nil		1	

Table 2: Secondary Procedure

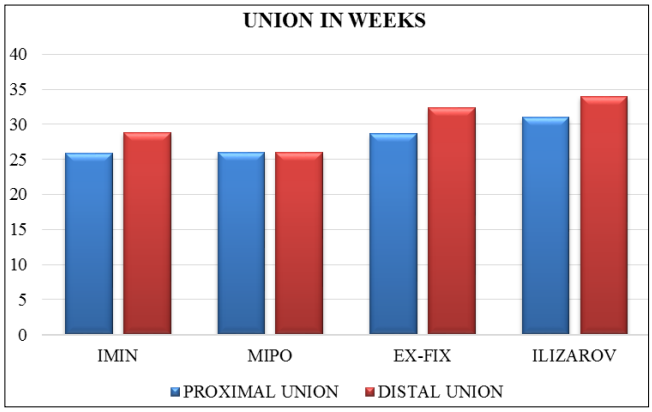
Secondary Procedure	Total
Dynamisation	5
Bone grafting	7
Augmentation plating	2
Wound debridement	4
Flap cover	1
Primary procedure conversion	3(IMIN to Ilizarov-1,Ilizarovto exfix-1,exfix to Plating-1)
Implant exit	2(IMIN)
Teriparatide supplementation	1



Graph 7: Outcome Analysis

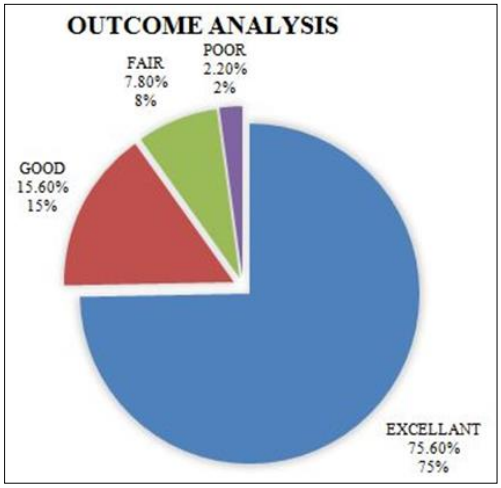
Table 3: Statistical Analysis

Treatment Methods	Statistics	Proximal union	Distal union
IMIN	Mean	25.91 wks	28.88 wks
	N	32	32
	SD	5.613	4.844
MIPO	Mean	26.00 wks	26.00 wks
	N	5	5
	SD	5.099	3.742
External fixation	Mean	28.67 wks	32.33 wks
	N	6	6
	SD	9.092	8.524
Ilizarov	Mean	31.00 wks	34.00 wks
	N	2	2
	SD	7.071	5.657
	Chi-square	1.464	3.735
Kruskal wallis test	df	3	3
	Asymp.sig	0.691	0.292



Graph 8: Union inweeks

The end results based on the final functional outcome of the patients in the study using Johner and wruch's criteria shows the following data : excellent -75.6%, good-15.6%, fair -6.7%,poor-2.2%



Graph 8: Overall outcome analysis based on Johner and wruch's criteria

Based on the above mentioned parameters IMIN has the excellent outcome followed by Plating, External fixation.

Discussion

This study is an attempt to study the long term results of operative management of segmental tibia fracture treated by Intra medullary nailing or plating or external fixator or ilizarov fixation in a standardized and objective manner. Factors affecting the quality of fixation and functional outcome have been analysed. The results have been studied in depth with a view to outline guidelines for better management of these fractures.

45 cases of segmental fracture of tibia were surgically treated by the mentioned modalities of management.

Males 86.7% (39 cases) are more commonly affected than females 13.3% (6 cases). 57.8 % cases (26 cases) were closed injuries, 42.2 % open injuries. Based on gustilo Anderson classification 1 grade -1 injury,9 grade 2 injury,6 grade 3a injury and 3 grade 3b injury. Age group of 40-60 years were most commonly affected with the study group aging from 18 to 65 years.

Right limb 64.4% (29 cases) involvement is more than left limb (16 cases) 35.6%.

Based on MELIS classification type 1 is most common 53.3% with 24 cases, type 2 has 28.9% with 13 cases, 13.3% type 3

with 6 cases, 4.4% type 4 with 2 cases.
Surgery was done on day 1 to a maximum of 20 from injury based on associated injuries and general health of the patient. About 37 cases 82.2%were operated within a week of injury.
Post operative complications were noted in about 44.4 % which needed secondary procedures in about 40% of the total 45 subjects.

Fig 4: Various Modalities of management in our study

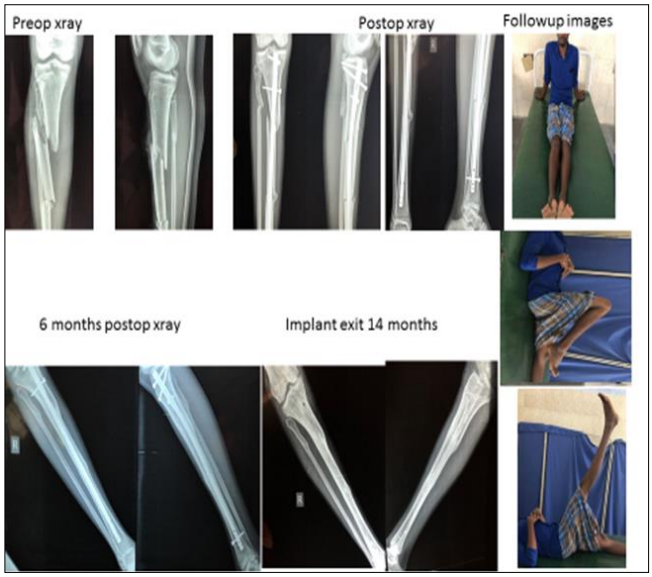
Segmental tibial fractures are uncommon injuries. They are commonly caused by high- energy trauma. It is estimated that many of these fractures are open, and often part of multiple injuries. They are challenging to manage and have a significant complication rate, and because of the wide zone of injury, potentially reduced viability of the bone and problems with stabilization. These high-energy fractures are likely to be associated with injuries elsewhere. (9AO) It is important to note that some of the segmental tibial fractures may require more than one surgery. The surgeon therefore, needs to plan ahead to make subsequent surgical interventions possible. There has been a significant change in the management of segmental tibial fractures. This has been made possible by the development of new orthopaedic implants. Various favoured methods of treatment have been currently proposed including casting and functional bracing, internal fixation by plates and screws, intramedullary nailing and external fixations. Nonoperative treatment of a segmental tibial fracture may need a long period of cast immobilization (35AO), from our experience, we have added that the weight of a high thigh cast with involvement of a joint above and a joint below was a more disabling factor that not endeared by both the patient and the Surgeon.
Charnley noted that a "double fracture of the tibia" should never be initially treated with an open operation as the danger of converting the central fragment into a tubular sequestrum was not worth the risk [1]. Langard and Bo stated that initial "non-operative treatment was considered essential" in many patients with segmental tibia fractures due to the high incidence of concomitant injuries. They used this algorithm even in the face of open fractures with non-operative treatment consisting of skeletal traction and plaster casting, going on to achieve union in 13 open and 7 closed fractures in 21 patients [2]. More recently Sarmiento reported on 48 closed segmental tibia fractures treated with casting and functional bracing with all fractures going on to union [3]. Conservative management should be reserved for low risk patients with a closed fracture, minimal shortening, and minimal angulation after a thorough discussion of risks and complications. Overall, surgery is the preferred treatment for segmental tibia fractures given the difficulty in maintaining an acceptable reduction in a functional brace or cast.In our study all segmental fracture of tibia are treated by surgical management.
Most surgeons advocate treatment of segmental tibia fractures with intramedullary nail placement in light of the significant difficulty and complications rates of other currently available treatment modalities. Intramedullary nail placement avoids many of the concerns related to other modalities such as control of length, rotation, alignment, dissection of the fracture site, disruption of the fracture vascularity, early weight-bearing, and incision site away from traumatic open wounds [10]. Duan *et al.*, in a Cochrane Review on intramedullary nailing for adult diaphyseal tibial fractures, was unable to draw a definitive conclusion on the best technique for intramedullary although moderate evidence suggests no clear difference in complications between reamed and unreamed nailing. They also noted that reamed nailing demonstrated a decreased incidence of implant failure, less re-operation related to nonunion, but this was only true in closed tibia fractures [14]. In 1969 Zucman and Maurer published their treatment of 36 segmental tibial fractures with unreamedKuntscher-type nails in a blind fashion. Of their 36 patients, 92% went on to union, but with 16% rate of septic union all present in patient who sustained open fractures [13]. In 1972 Pantazopoulos *et al.* reported on their results of blind unreamedKuntscher nailing of 13 segmental tibial fractures with one nonunion, no cases of infection, and no cases of malunion [12]. In 1981, Melis *et al.* detailed their treatment of 38 segmental tibia fractures with tight-fitting reamed Kuntscher-Herzog intramedullary nails and supplementation with immobilization in a long leg cast. With strict adherence to this algorithm, in 22 closed and 16 open fractures, they reported one malunion, one non-union, and one infection [11]. Woll and Duwelius reported on their treatment of 31 segmental tibia fractures with seven fractures being treated with unreamedLottes' nails and the remaining fractures were treated with External fixation, plate osteosynthesis, and nonoperative treatment. Of the four treatment modalities unreamed unlocked Lottes' nails demonstrated the lowest complication rate of 40% which included malunion and nonunion [6]. The authors were convinced that the high rate of nonunion and malunion was related to the lack of distal rotational control and hypothesized that distally locked intramedullary nails would provide less complications. Wu and Shih treated 38 segmental tibial shaft fractures with reamed interlocking intramedullary tibial nailing and achieved a union rate of 97% without any deep infections, clinically significant malalignment, or implant failures. Huang *et al.* treated 33 segmental tibia fractures with this technique. This

series detailed rates of 3% malunion, 9% delayed unions, no cases of nonunion, and 6% deep infection rate which occurred in two of the reported open fractures [9]. Giannoudis *et al.* treated 27 cases of segmental tibia fractures with 14 unreamed locking intramedullary nails, 2 reamed locking intramedullary nails, and the remaining 11 cases were treated with other various modalities. There were a large number of complications with 8 of 14 unreamedtibial nails undergoing a secondary procedure to achieve union, eradicate infection, or to undergo amputation [7]. These principals in mind, Kakar and Tornetta followed 51 patients to union with segmental tibia fractures treated with unreamed locked intramedullary nail placement with only a 9% revision rate [10]. Most recently Terra *et al.* compared healing in matched controls of 30 segmental and non segmental tibia fractures treated with 18 unreamed locked intramedullary nails, 4 reamed locked intramedullary nails, 3 plate osteosynthesis, and 5 external fixation. The preferred treatment was unreamed locked intramedullary nailing, but the authors report a greater than 55% rate of reoperation to obtain union [8]. Total 32 cases were taken for intramedullary implant all were done in closed reduction manner.

The average intra-op blood loss was 125 ml. The patient is positioned supine on a radiolucent table. The ability to flex the knee by at least 90 degree is required. A closed reduction is performed under image intensifier guidance. The required nail length is determined using the radiographic ruler. The possibility of axial shortening due to primary compression or secondary dynamisation must be considered when determining the nail length. In our study we use only midline patellar tendon splitting approach. In the present study, early weight bearing exercise was started considering fracture pattern, bone and soft tissue condition. As nail being a weight sharing implant, it also helps in preventing regional osteoporosis. Initially partial weight- bearing exercise is started. Once it was tolerated by patient, gradually load was increased on fractured limb. Weight bearing exercise is essential for building and maintaining healthy bones. In the present study, when patients begin weight-bearing activities, fracture pattern, fracture localization, the condition of the soft tissue and the quality of the bone should be taken into account.

In Imin group Based on the nature of injury 23 were closed and 9 open injuries. Mean time for union took longer in open cases than closed cases. Gustilo Anderson grade 3 a segmental tibia fracture treated with ETIN with inter fragmentary screws had delayed union and infection hence wound debridement and nail implant removal done followed with ilizarov fixation as a secondary procedure. With proper wound care and followup the patient had a good union and range of motion. A patient with Gustilo Anderson classification grade 2 with type 2 diabetes developed superficial infection which was controlled with culture specific oral antibiotics and diabetic control. Most common postoperative complication is angulation which was reported in eight cases. Angulation of less than 10° was managed with postoperative POP cast Immobilization. Angulation more than 10° were corrected by secondary procedure means of augmentation plating. Delayed union was noted in six casesWhich was subsequently treated with dynamisation and bone grafting. Shortening less than 1.5 cm were considered insignificant and not noted as a complication. Anterior knee pain noted in 2 cases were treated analgesics and physiotherapy. Reamed nailing union time was similar to that of non reamed nailing method.our study based on Melis classification of segmental tibia fracture type 1 Melis was found to be more common. All the type 1 Melis fracture were treated with unreamed nailing. Type 4 Melis with long intermediary segment unites faster and better than other types treated with nailing. Proximal fracture in segment tibia unites faster than distal segment tibia fracture. Suggesting better muscle coverage near the proximal end helps in healing fracture faster than distal end. We found that union was quicker in the proximal fracture sites than distal, and more in the postero-lateral part of the tibia than the antero-medial part; this may be due to better blood supply and more soft tissue coverage in this area. Segmental fractures are more prone for malalignment-anterior angulation and valgus deformity.Proper preoperative planning and specific implant (advent of expert tibia nail, herzog bend modification) selection needed for reduction. Reduction of segmental fracture involves various techniques like poller screws, joystick manoeuvre, distractors, Buttress plate, interfragmentary screws. Malalignment which are particular for proximal segment tibial fractures could not be avoided completely in all cases but postoperative timely intervention had resulted in excellent to good final outcome.

Case Illustration -1



In plate osteosyntheses group, All cases were operated on using the MIPO technique under fluoroscopic control. 1976 Langàrd and Bø treated 23 segmental tibia fractures with plate osteosynthesis and found a complication rate of 26% and 57% for closed and open fractures, respectively [2]. In a series of 22 patients treated with plate osteosynthesis published in 1989, Rommens*et al.* found a 60% complication rate with greater than 25% chance of wound complication and infection. Not surprisingly, approximately 20% of tibias went on to develop pseudarthrosis with some progressing to implant failure [5]. Several additional series of segmental tibia fractures use plate osteosynthesis sparingly with infection and wound complications being almost universally described [5, 6, 8]. But with the advent of MIPPO and better understanding of fracture biology and a anatomical alignment plate fixation through minimally invasive technique propagand as a novel method. The patient was placed in the supine position on the operating table, and a tourniquet was applied without exsanguinating the leg. Indirect reduction of the fracture was achieved and maintained with traction. The skin was incised approximately 2-4cm distal or proximal to the fracture site

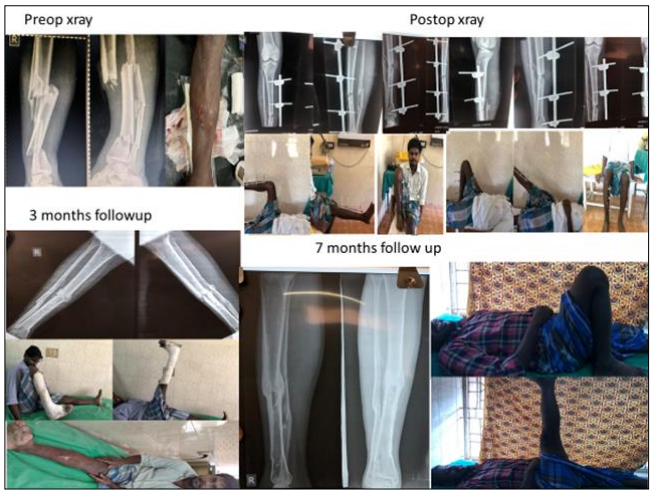
depending on the fracture location, and the pre-contoured locking compression plate (LCP) was fed subcutaneously across the fracture site without dissection of the periosteum if it remains intact. A locking drill guide was introduced into the end of the screw hole and used as a "joystick" to push the plate and reduce the displacement. Following insertion of the plate, correct positioning of the plate was confirmed by a minimum of two fluoroscopy views. One locked screw was placed in the end hole at the site of insertion. Fracture reduction was then reconfirmed by fluoroscopy before placing a second screw at the opposite end of the plate through a stab incision. Fluoroscopy was performed again to check alignment. With separate stab incision, additional fixation was achieved with screws at either end of the plate so atleast three screws on either side. The placement of a locking compression plate (LCP) using the MIPO technique minimizes the trauma to the injured zone, preserves the circulation around the fracture site and provides better fixation in the osteoporotic bone. The technique minimizes the soft tissue trauma to the injured zone, which theoretically provides better preservation of the blood supply around the fracture area [17]. Even though MIPO requires greater exposure to radiation because of the performance of closed indirect reduction, it may be advantageous for the treatment of segmental tibia fractures because it minimizes soft tissue damage and revascularization of the fracture fragments and lowers the risks of infection, nonunion and other complications. Collinge and Sanders described indirect fracture reduction and percutaneous plating techniques for the treatment of fractures in the lower extremity as novel biological plating techniques [18]. However, some studies have also revealed disadvantages of the MIPO technique. Hasenboehler *et al.* reported that although MIPO seems more advantageous for soft tissue and bone biology, prolonged healing times were observed in patients with simple fracture patterns [19]. Khoury *et al.* noted that for the MIPO technique, reduction should be performed cautiously due to the tendency of sagittal plane malreduction [20]. Segmental fractureof tibia are not usually amenable to closed reduction method and fractures at times fails to unite. Boutin (1956) pointed out the bad prognosis of this fracture. Zucman and Maurer (1969) recommended blind intramedullary nailing, but with two fractures on which to thread the nail the technique is not easy, H.N.burwell found plating to be little more difficult than with a single fracture, care being taken to avoid stripping the middle fragment, and one or two plates being used, depending on the length of this fragment [21]. The MIPO technique only requires realignment of the tibial mechanical axis, and clear exposure of the fracture is not necessary. An intraoperative image intensifier may help with the closed reduction and avoids excessive disturbance of the fracture fragments. In our study 5 cases where managed with plate osteosynthesis by mipotechnique, the age group involved was between 30 to 58 years, 2 closed injury and 3 open injury. 1 case was involved with fracture distal femur and patella which was subsequently treated with orif plating distal femur, the patient had a gross communition in the femoral segment post-operatively developed shortening of 5cm, which was treated with shoe heel raise and rigours physiotherapy. No other significant complications noted in the plating mipo group. A grade II compound injury, proximal tibia was fixed with plating and for the distal fragment because of the wound condition primary external fixation was done. knee and ankle mobilisation was started within a week of surgery the patients in the mipo group post-operatively stabilised with pop for two weeks, since the soft tissue handling given greater respect no complications such as infection and wound necrosis not noted, compared to imin delayed weight bearing was noted. Mean union time for proximal segment and distal segment was noted to be 26 weeks. The mean time take for union in proximal and distal segment was found to be the same. Closed injury unites faster then open injury in mipo group. Three case were of mellis type I and 2 case were of type III Melis. The cases with proximal condylar involvement with good soft tissue coverage mipo would be ideal. The final functional outcome in primary mipo group based on johner and wruch`s criteria is excellent in four cases and good in one case. The time taken for full weight bearing was found to be prolonged compared to imin group. Based on johner and wruchs criteria final outcome shows excellent in 26 cases and good in cases.

Case Illustration -2

External fixation provides a viable treatment option for many segmental tibia fractures as it provides stability to a grossly unstable injury while avoiding hardware near the site of the often associated soft tissue injury. This method is thought to "leave a small footprint" and maintain the biology of the fracture in a comparable manner to conservative treatment [4]. Rommens *et al.* reported on 18 fractures treated with external fixation of which 50% were complicated by "bone-healing disturbances" to include pseudarthrosis, refracture, delayed union, and malunion [5]. This increased rate of bony union complications was thought to be related to the lack of stability in bi-dimensional planes [5]. Woll and Duwelius reported a complication rate of 55% for infection, malunion, and nonunion in the care of 20 segmental tibia fractures treated with external fixation [6]. Giannoudis *et al.* achieved a similar deep infection and malunion rate of 50% when treating 8 segmental tibia fractures with external fixation [7]. Circular external fixation has the advantage of circumferential control, post surgical correction outside of the operating room, capture all fracture segments, provides minimal disruption of fracture biology, and possibly allows almost immediate partial weight-bearing [4]. Usually a sequential protocol of treating compound fractures are initial debridement, external fixation, closure of the wound, intramedullary interlocking nail with reaming [6]. The disadvantage of this technique is the need for several operative procedures and longer period of hospitalization. The infection rate of fractures which were first treated by external fixation and then with Intramedullary interlocking nailing was significantly much higher than those fractures treated with Intramedullary nailing alone [7]. A high

incidence of infection is noted secondary to the delayed intramedullary nailing and the need for several procedures. External fixation alone helps to return the patient to full function as soon as possible and not make the patient to undergo several operative procedures [8, 9] and burden the poor patients economically in which external fixation can be used as primary and definitive line of management for open fractures tibia which is very cost effective [10]. The commonest complications that occur after external fixator in tibia are nonunion, deformity, shortening, knee- ankle stiffness following prolonged application of fixator. The conventional AO external fixator can be now replaced with limb reconstruction system (LRS) depending upon the location of wound, need of much fracture stability. Due to its anterior placement on tibia, LRS is more accessible to patient for pin tract care. LRS may be the better option in primary management of compound tibia fracture in terms of initiation of early weight bearing, more rigid fixation. LRS has also been proven effective in treating commonest complication following compound injury in tibia i.e. nonunion, deformity correction, reconstructive procedure for gap nonunion using bone transport and limb lengthening. The above methods have been carried out in infection. Hence, to avoid application of multiple fixator system in same patient, LRS may prove single tool method to deal with primary and definitive treatment tool to manage soft tissue wounds and bony discontinuities. The complication of bone–pin interface i.e. pin loosening are very less and occur very late in LRS system, hence the LRS can be used for multiple procedures after single application. In our study 6 patients were treated with primary external fixation, all the 6 subjects were open injurie. 2 grade II, 3 grade I and 4 grade IIIA compound injury, all the surgeries with external fixation was done on day one itself under spinal anaesthesia after wound irrigation and through debridement with proper antibiotic coverage. We used conventional AO uniplanar external fixator in three cases, 1 case with grossly communited segment with bone loss, secondary procedure with removal of external fixator and plating with fibular strut grafting. Another case had a complication of distal angulation and delayed union which was treated by external fixator removal at distal site and controlled manipulative correction done and stabilised with pop cast and delayed union was treated with teriparatide supplementation, in this case the proximal segment united at 28 weeks and the distal segment at 32 weeks. A grade III open injury treated with external fixator -LRS went for wound necrosis and infection followed with wound debridement and higher antibiotics and vacuum dressing.then secondary procedure with flap coverage was done based on mellis classification three mellis type I and three mellis type II were present. The mean union time for proximal segment is 28.67 weeks and distal segment is 32.33 weeks. All the external fixator were removed at the range of 16-20 weeks. In which wound finally settled with acceptable callus formation in in antero-posterior and lateral radiographs and managed with patellar tendon weight bearing cast, and allowed full weight bearing. The final functional outcome in external fixator group based on johner and wruch criteria were found to be excellent in three cases, good in one case, fair in one case and one case had a poor outcome. Delayed and cautious weight bearing were noted in external fixator.

Case Illustration -3



Case Illustration -4

Ilizarov external fixation has the capacity to provide multilevel stabilization of the fracture with minimal disturbance to the soft-tissue envelope. It gives multiplanar control which is absent from monolateral designs. It leaves a very small “footprint” on the biology of the fracture and is almost equivalent to conservative methods if fixation pins are kept away from the fracture zones except from the patient can able to weight bear immediately after surgery and this produces a micro movement at fracture site and this serves as a stimulus for callus formation. Ilizarov external fixators were commonly used for grade III compound segmental tibia fractures. It has the advantage of circumferential 360 degree control, postsurgical deformity correction outside of the operating room, capture all fracture segments, provides minimal disruption of fracture biology, and possibly allows almost immediate partial weight-bearing. Most common complication is patient intolerance and pin tract infection. But this can be managed with a short course of antibiotics. Ozturkmen *et al.* [15] demonstrated successful treatment of 24 adult patients all of whom went on to union with good to excellent function results. Giotakis *et al.* [4] used circular external fixation to include Ilizarov and Taylor Spatial Frame in the treatment of 20 segmental tibia fractures. Of which there were 2 nonunion treated with either continued external fixation or revision with bone grafting. 2 grade IIIB compound segmental fracture are managed with ilizarov, 2 cases mellis type I in one case and type II in one case the patients were taken up for surgery within 48 hours of injury.

one case was associated with shortening of 4cm and vagus angulation, this patient also had ipsilateral compound distal femur fracture which was treated surgically. The shortening was treated with heel raise and patient was in need of physiotherapy for a longer time.the second case treated with ilizarov had delayed union with wound infection and patient wanted discomfort with ilizarov apparatus, hence wound debridement with ilizarov removal with secondary procedure of knee spanning external fixator with antibiotic beads the antibiotic bead were removed after three weeks wound settled, early weight bearing was noted in ilizarovgroup. The time taken for union for proximal segment and distal segment were 31 and 34 weeks respectively. Based on johner and wruch criteria both the case have fair outcomes.

Both the imin and mipo group have similar union rates, the mean time of union is longer in external fixation methods compared to that of internal fixation

The mean union time in closed injury is shorter than that of compound cases. Closed injury heals better, unites faster and functional outcome is better than that of compound injury

Calcaneal traction with gradual increasing in weight is a very important prilimanary method to aid in closed reduction in significantly displaced segmental fracture are when the skin viability is doubtful as a provisional initial management.

Segmental tibia fracture must be distinguished among tibial fractures because of the different trauma context, difficulties encountered in solid fixation and slow bone healing the anatomical type of fracture, presence of proximal metaphyseal involvement, compartment syndrome and the presence of soft tissue damage determines the modality of management. New radiological criteria for bone healing should be defined for these fractures due to the longer time to cure. Compromised blood supply to the intermediary segment and to both segments, requires an interventional approach if osteogenesis lacks vigor

The MIPO technique is more advantageous in terms of infection and soft-tissue protection than open reduction and internal fixation, but it is thought that the implant is in the intramedullary canal, and because IMN has fewer exposed parts, it is less affected by the soft tissue's condition. Both the imin and mipo had cosmetic appeal to the patients, when the treatment options explained to the patient, patient showed hesitancy towards external fixation methods. From our study internal fixation with minimal scar are in favour of general public. These internal fixation methods also show better outcomes. Even though imin is to be reported with complications and need for secondary procedures based on the advent of intramedullary implants and the economic implications with early weight bearing and final favourable outcomes appeases the eye of the people and the mind of the surgeon, this can be seen in our study, as 32 of the 45 cases treated primarily with intramedullary implant.

We noted less complications with mipogroup, this study has limitations as statistical analysis would not yield accurate outcome due improper sample size. Malalignment and delayed union are the most common complications addressed if timely intervention with secondary procedures done, we can expect a final positive outcome, with the advent of higher antibiotics, vacuum dressing and sterile primary wound debridement incidence of infection pods-operative decreased comparatively decreased compared to other studies. Giannoudis *et al.* reports that 66.6% of segmental fracture tibia require more than surgical intervention [16]. It is therefore extremely vital to plan ahead so that subsequent surgical interventions become necessary, the surgeon should be well prepared for it. The need for secondary procedures longer rehabilitation time, complex nature of the injury, prolonged physiotherapy need to be addressed and the possibilities of surgical methods and outcomes are to be counselled to the patients and attenders at the time of injury

External fixation and ilizarov methods are associated with higher incidence of complications, and are to be reserved for high velocity compound communited complex segmental fractures of tibia.

We conclude that these injury are caused by high energy trauma involving complex segment fracture with soft tissue damage. Hence proper clinical assessment of soft tissue is vital and timing of surgery is important. Preservation of vascularity of intermediate segment and non-traumatic reduction of fracture fragment, require expert surgical skill. Experience regarding appropriate usage of variable available implants make the surgical procedure with excellent functional outcome. Each various modalities has own merit and pit falls but in reality study /research lack in definitely proving superiority of one over the other. This study of 45 segmental fractures, with unequal sample size distribution in various modalities of management may help in determining the choice of management of segmental fracture tibia while its course in study in functional and radiological outcome.

Fig 5: Complications management

Conclusion

We emphasize on that the management of the segmental fractures poses a formidable change to the treating surgeon, as number of available implants has escalated dramatically over the last decades and the treating surgeon is simply overwhelmed by these implants and the new concepts and surgical techniques that accompany them. Lastly we strongly agree with Ching-Kuei Huang *et al.*, that there are no clear therapeutically- relevant guidelines regarding classification of segmental tibial fractures treatment, approaches and evaluation of functional outcome.[9]

The results of our study suggest that if soft-tissue handling and restoration of anatomical alignment are successful in the treatment of challenging segmental tibial fractures, both IMN and MIPO will be good treatment methods.

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