DISCUSSION

Incidence of fractures of long bones is increasing day by day due to increased road traffic accidents and other domestic accidents. The shaft of the tibia is one of the most common sites of an open fracture as one third of its surface is subcutaneous. Open fractures of the tibia are associated with massive soft tissue injury and bone loss with high rates of infection and nonunion resulting in poor treatment outcome. The treatment goals include prevention of infection, soft tissue coverage and fracture stabilization leading to union with simultaneous mobilisation of nearby joints enabling early return to function. The specific method of skeletal fixation and soft tissue management in open fractures continues to be a topic of debate in orthopaedic traumatology with the treatment options ranging from external fixators, Ilizarov fixators, nailing, plating, tibial synostosis, free or vascularized bone grafting along with allografts or bone substitutes, all having their own set of complications. Treatment protocol of compound fractures involves thorough initial debridement and external fixation followed by closure of the wound either by flap rotation or skin grafting. Then intramedullary interlocking nailing or plating with or without bone grafting is done as a secondary procedure.

The disadvantages of this technique are higher incidence of infection than closed fractures treated with intramedullary nailing alone; need for several operative procedures, longer period of hospitalization and increased economic burden to the already poor patients. Stabilization of

compound fractures of tibia by external fixators promotes soft tissue healing, preserves the bone vascularity, accessibility to wound and causes less blood loss. Traditionally complex nonunions and open fractures are managed by the Ilizarov ring fixators but it is heavy and complicated to manage, both for the surgeon and the patient. Limb Reconstructive System (LRS) is a modular unilateral frame consisting of Shanz pins, rail rods and sliding clamps. It is simple, effective, adjustable, light weight and offers rigid stabilization of fracture fragments along with access to wound dressing. The management of open fractures with the LRS fixator allows immediate functional stabilization of fractures, weight bearing and axial fracture site movement promoting an early callus response and fracture union.

Hence; the present study was undertaken in the Rajindra Hospital and Govt. Medical College, Patiala for assessing the functional outcomes of monorail fixator as a primary mode of fixation in compound tibia fracture type 2 and type 3A,3B as classified by Gustillo-Anderson. The 30 cases of compound tibia fracture were selected and followed up.

Age Incidence

In our study we include patients aged between 18 and 60 years and the maximum numbers of patients were 43.33 percent belonged to the age group of 41 to 50 years while 16.67 percent of the patients belonged to the age group of 51 to 60 years. 30 percent of the patients belonged to the age group of 31 to 40 years. The youngest being at age 21 and the oldest being 58 year of age. Mean age of the patients was 42 years. Our results were in concordance with the results obtained by previous authors who also reported similar findings. In a study conducted by Singh P et al, mean age of the patients was 35.5 years.

Mean age of the patients in the studies conducted by Kale AB et al and Thakur et al was 35.6 years and 38 years. In other

studies, conducted by Mahajan NP et al, Pangavane P et al and Patil NVP et al, mean age of the patients was 37.85 years, 37.9 years and 44 years respectively.

Study	Mean age (years)
Singh P et al	35.5
Kale AB et al	35.6
Thakur et al	38
Mahajan NP et al	37.85
Pangavane et al	37.9
Patil NVP et al	44
Present study	42

Sex Incidence

In our study, there were male dominance which may suggest higher level of activities and mobility among male population. The 93.33 percent of the patients were males while the remaining 6.67 percent were females. Our results were in concordance with the results obtained by previous authors who also reported male preponderance in their respective studies. In the studies conducted by Mahajan N et al, Kale AB et al and Thakur et al, 65%, 93.33 % and 83.5% of the patients were males respectively.

Study	Males (%)
Singh P et al	75
Kale AB et al	93.33
Patil NVP	70
Mahajan et al	65
Thakur et al	83.5
Present study	93.33

Mode of Injury

In our study, most common cause was road traffic accident in 83.33 percent of the patients while it was fall from height in 16.67 percent of the patients. These fractures are usually related to high energy trauma associated with road traffic accident. Our results were in concordance with the results obtained by previous authors who also reported that road traffic accidents were the major etiologic factors in their respective studies. In the studies conducted by Singh P et al, Kale AB et al and Mahajan NP et al, road traffic accidents were etiologic factors in 80%, 100% and 65% of the cases respectively.

In the study conducted by Antich-Adrover P et al, road traffic accident was the major cause of injury in 81.9% of patients where as in Thakur et al series, 87.3% of patients with open fractures were caused by road traffic accidents.

Study	Road traffic accident (%)	Others (%)
Singh P et al	80	20
Kale AB et al	100	0
Mahajan NP et al	65	35
Present study	83.33	16.67

Types of Fracture Classification

According to Gustilo-Anderson classification we included in our study from type II to type III B. In our study 53.33 percent of the patients were belonging to type III A while 33.33 percent of the patients were of type III B. 13.33 percent of the patients were of type II.

In the study conducted by Singh P et al, 7 (35%) had Grade II fracture, 8 (40%) had Grade III A fracture and 3 (15%) had Grade III B fracture. Mahajan NP et al, in another study reported that according to Gustilo Anderson classification, 5 (25%) cases were of grade I, 3(15%) cases were of grade II, 5 (25%) cases of were grade IIIA and 7 (35%) cases were of grade IIIB. In another study conducted by Granhed et al, 45%

of the patients were of the type 3b and rest 55% patients were belonging to type 3c Gustilo- Anderson group.

Type of fractures (Gustilo-Anderson classification)	Singh P et al	Kale AB et al	Present study
II (% of patients)	35	50	13.33
III A (% of patients)	40	10	53.33
III B (% of patients)	15	33.33	33.33

Side of Injury

In our study Right side involvement occurred in 73.33 percent of the patients while left side involvement occurred in 26.67 percent of the patients. Similar results were reported in the study conducted by Singh P et al who observed involvement of right side in majority of the cases.

Study	**Right side (%)**	**Left side (%)**
Singh P et al	60	40
Present study	73.33	26.67

Duration of Surgery

The Mean duration of surgery was 52.17 minutes. In our study the minimum and maximus duration of surgery was 35 minutes and 90 minutes respectively. The maximum duration of surgery was due to a comminuted fracture in which achieving proper reduction was difficult. Our results were in concordance with the results obtained by previous studies who also reported similar findings. In a study conducted by Singh P et al, in 16 (80%) cases operation time was 45 minutes while in the rest 4 (20%) cases duration of surgery was about 1 hour due to difficulty in achieving proper reduction and placement of implant. In a study conducted by Akhtar A et al, mean duration of surgery was 60

minutes.

Study	Mean duration surgery (minutes)
Akhtar A et al	60
Present study	52.17

Secondary Procedure

In our study, Secondary procedures (Skin Grafting) were done in 40 percent of the patients. All the grafting procedures were carried out in patients with Gustilo-Anderson classification 3A and 3B.

- Regular dressing of these open wound with appropriate antibiotics administration was done in postoperative wards.
- After 2-3 weeks, once the wound is clean and covered with healthy granulation tissue plastic surgeon opinion was taken and treated accordingly.
- In our series 12 patients needed skin grafting and rest heal without any plastic surgery interventions. Out of 12 patients who underwent skin grafting in all 12 cases graft took up well and they were discharged later after the wound had healed up.

In a study conducted by Singh P et al, Adequate soft tissue coverage was done with split skin grafts for 2 (10 percent) and local flaps for 1 patient (5 percent) after 3-4 weeks and took up well.

Study	Secondary procedures (%)
Singh P et al	15
Kale AB et al	46.67
Present study	40

Time of Full Weight Bearing Post-Operative

In our study the mean time of full weight bearing post-operative was 5.37 days. The maximus time taken for full weight bearing was 15 days in the patient with ipsilateral 3rd and 4th metatarsal bone fracture. One patient with

contralateral shaft femur fracture and two patients with contralateral shaft tibia fracture managed with intramedullary nailing postoperative 4th day of rail fixation. These patients take more time to full weight bear postoperatively.

Variable results have been reported in this context in the past literature.

In the study conducted by Singh P et al, mean time to full weight bearing was 10.45 days. Kale AB et al reported the mean time to full weight bearing to be 6.3 days.

Study	Time of full weight bearing (days)
Singh P et al	10.45
Kale AB et al	6.3
Present study	5.37

Time of Fracture Union

In our study, the 50 percent of the patients, time of fracture union was 24 weeks to 30 weeks, while in 23.33 percent of the patients; time takes to fracture union was 31 to 35 weeks. Mean time of fracture union was 31.8 weeks. Patient with comorbidities like DM, HBV, HCV Infection were taken more time to fracture union. Our results were in concordance with the results obtained by previous authors who also reported similar findings in their respective studies. Mean time of fracture union in the studies conducted by Singh P et al and Ajmera A et al was 23.26 weeks and 52 weeks respectively.

In the studies conducted by Patil NVP et al and Pangavane P et al, mean time of fracture union was reported to be 35 weeks and 41 weeks respectively. Mahajan et al reported the mean time of fracture union to be 20.22 weeks. Thakur et al, Chandraprakash et al reported mean bony union time to be 20 weeks and 22 weeks respectively.

Study	Time of fracture union (weeks)

Singh P et al	23.26
Ajmera A et al	52
Patil NVP	35
Pangavane P et al	41
Present study	31.8

RUST score (Radiographic Union Scale in Tibia)

In our study 33.33 percent of patients presented with RUST score 2 and 63.33 percent with RUST score 3. One patient (3.33 percent) had RUST Score 1 after three consecutive follow-up Xrays. This patient treated with removal of fixator, debridement, sequestrectromy and fracture refixation with Ring fixator and bone grafting.

All the patients with RUST score 2 advised protected weights bearing with patellar tendon bearing cast for 3 weeks post fixator removal.

Complication

In our study Overall complications were seen in 9 patients. Most of the patients showed complication had comorbidities like DM, HBV and HCV infection. Three patients (10%) showed isolated delayed union of fracture, two patient (6.67%) showed isolated pin tract infection, one patient (3.33%) had surgical site infection, one patient (3.33%) developed pin tract infection along with nonunion and remaining two patients (6.67%) showed presence of pin tract infection along with delayed union. In the patient with surgical site infection, debridement was done with broad spectrum IV antibiotics administered. Once the infection was subsided skin grafting was done. Pin tract infection was treated with IV antibiotics according to culture and sensitivity. Two patients showed presence of pin tract infection along with delayed union required pin removal because of pin loosening and was treated by replacement of new schanz pin over nearby slot

in connecting clamp. One patient showed presence of deep pin tract infection along with nonunion required removal of fixator, debridement, sequestrectromy and fracture refixation with Ring fixator and bone grafting.

	Studies	**Complications (%)**
Sing P et al (2020)	Pin tract infection	20
	Delayed union	10
	Pin loosening	15
Kale AB et al (2017)	Pin tract infection	26.67
	Malunion	3.33
	Nonunion	3.33
Present study	Isolated pin tract infection	6.67
	Isolated delayed union	10
	Surgical site infection	3.33
	Pin tract infection +Non union	3.33
	Pin tract infection + Delayed union	6.67

In the study conducted by Singh P et al, pin tract infection was found in 04 (20%) cases which healed by pin tract dressing. Delayed union was observed 02 (10%) cases. Joint (knee or ankle) stiffness was observed in 03 (15%) cases. Loosening of pin was observed in 03 (15%) cases. Shortening and chronic osteomyelitis were not observed in any of the cases. One of the patients of type III B fracture ended up with infected nonunion. This patient was treated by debridement, sequestrectromy and refixation with LRS fixator. Corticotomy and bone transport was done to replace the excised portion of the bone.

Ajmera A et al, in another study reported that pin tract infection was seen in 5 cases, out of which 4 being superficial, which healed to dressings and antibiotics. One patient had a deep infection

which required frame removal.
In the past studies, the most common complication, in accordance with previous studies, was pin tract infection which was seen in 8 (28%) of our patients, 5 (16%) had limb shortening, which healed on suitable parenteral antibiotics after culture and sensitivity (Robert Rozbruch S et al, Sen C et al, Mekhail AO et al).

Outcome according to Modified Johner and Wruh's criteria

According to Modified Johner and Wruh's criteria,excellent results were seen in 76.67 percent of the patients that means there was no non-union, no infections, no deformity, no shortening, no pain, full range of ankle and knee movements, no neurological deficit and normal gait. while in 13.33 percent of the patients shows no non-union, mild infections, occasional pain, range of ankle (>75%) and knee (>80%)movements, no neurological deficit and normal gait that means good outcome. 6.67 percent of the patients showed fair results in the form of no non-union, moderate infections, moderate pain, range of ankle (>50%)and knee movements (>75%), no neurological deficit and mild limp while 3.33 percents shows poor outcome by non-union, deep infections, severe pain, range of ankle movement (<50%) and significant limp.

Our results were in concordance with previous authors who also reported similar findings. In a study conducted by Ajmera A et al, Functional results were excellent in 84% (21/25), good in 8% (2/25) and fair in 8% (2/25). Excellent results were seen in 79.63 percent of the patients in the study conducted by Patil MY et al while good results were seen in 12.96 percent of the patients.

In a study done by Vijay et al on management of open tibial fractures with LRS rail external fixators, overall, 90% of the fractures united well: excellent to good results were seen

in 72%, fair in 18% and poor in 10% of cases based on the modified Anderson and Hutchin's criteria. Lakhani et al used rail fixator system in reconstructing bone gap and reported that union was achieved in all the cases.

Studied		Percentage
Patil MY et al	Excellent	79.63
	Good	12.96
	Fair	7.41
	Poor	
Singh P et al (2020) [Functional outcome]	Excellent	70
	Good	20
	Fair	5
	Poor	5
Lakhani A et al	Excellent to good	85
	Poor	10
Pal CP et al	Excellent	68.75
	Good	18.75
	Fair	12.50

Kale AB et al (Modified Anderson and Hutchinson's criteria)	Good	78
	Moderate	18
	Poor	4
Akhtar A et al (Modified Johner and Wruh's criteria)	Excellent	43.33
	Good	33.33
	Fair	16.67
	Poor	6.67
Present study (Modified Johner and Wruh's criteria)	Excellent	76.67
	Good	13.33
	Fair	6.67
	Poor	3.33

Microbiological profile & Antibiotic sensitivity pattern

Microbiological culture and sensitivity testing was sent in 6 patients in whom complications of infection were seen. Among these 6 patients, Escherichia coli were seen in 2patients (33.33 percent) while staphylococcus aureus was seen in 4 patients (80 percent). Antibiotic sensitivity of E. coli was seen for Amikacin, Gentamicin, Ceftriaxone, and Cotrimoxazole. Antibiotic resistance of E. coli was seen for Ciprofloxacin, Ampicillin. Antibiotic sensitivity of Staphylococcus aureus was seen for Amikacin, Clindamycin,

Vancomycin, Ampicillin and Ceftriaxone while resistance was seen for Erythromycin, Gentamicin and ciprofloxacin

According to Yokoyama K, treatment of grade IIIB and IIIC

with intramedullary nailing was risky as it leads to deep infection and nonunion in 20.3% cases. Therefore, external fixators are preferred modality because they are easy to use and allow soft tissue treatment. But the problems associated are prolonged immobilization and need for revision surgery for definitive fixation at a later stage. Therefore, LRS, which is different from the simple external fixators in allowing full weight bearing immediate postoperatively like an intramedullary fixation was used. LRS fixation technique also has an added advantage of salvaging the limb and preventing amputation. On other side, it has its own complications like pin loosening and pin tract infection.

Summary

The present was conducted to evaluate the functional outcome of monorail fixator as a primary mode of fixation in compound tibia fracture as classified Gustilo-Anderson type 2 and 3A, 3B wound in 30 cases presented in the Department of Orthopaedics, Rajindra Hospital and Govt. Medical College, Patiala.

Following results were obtained which summaries here-

- Open fractures are slightly predominating in the age group between 31-50 years of age (73.33%). Mean age of the patients was 42 years.
- Open fracture of tibia is common among males (93.33%).
- In our study, most common cause was road traffic accident in 83.33 percent patients.
- Most of the fractures were Gustilo Anderson type III (86.66%) and rest were type II (13.33%).
- Right side involvement (73.33%) is more than left side (26.67%) of the tibia.
- 16.67 % of the patients presented with associated injuries with primary compound tibia fracture.
- 26.67% of the patients suffered with comorbities.
- The mean duration for monorail fixation was 52.17 minutes.

- Secondary procedures like skin grafting were done in 40% of the patients.
- Full weight bearing with fixator was allowed 5.37 days of mean duration.
- Among 30 patients 10 percent of patients showrd isolated delayed union, 3.33 percent surgical site infection, 6.67 percent pin tract infection with delayed union while 3.33 percent of patients showed Nonunion associate with deep pin tract infection and 6.67 percent patients developed isolated pin tract infection as a complication.
- The mean time taken to unite the fracture was 31.8 weeks.
- Excellent result were seen in 76.67 percent of patients while 13.33 percent showed good result and 6.67 percent patients had fair result while 3.33 percent of patients showed poor outcome according to Modified Johner and Wruh's criteria
- Among these 6 patients of infection, Escherichia coli were seen in 2 patient (33.33 percent) while staphylococcus aureus was seen in 4 patients (66.67 percent) in pus culture.
- Antibiotic sensitivity of E. coli was seen for Amikacin, Gentamicin, Ceftriaxone, and Cotrimoxazole. Antibiotic resistance of E. coli was seen for Ciprofloxacin and ampicillin. Antibiotic sensitivity of

Staphylococcus aureus was seen for Amikacin, Vancomycin, Clindamycin, Ampicillin and Ceftriaxone while complete resistance was seen for Erythromycin and ciprofloxacin and gentamycin.