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Case Series

Functional outcome of limb reconstruction system in lower limb compound fractures: A prospective study

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Abstract

The study aims to assess the functional and radiological outcome of limb reconstruction system in lower limb compound fractures.

Open fractures of the lower limb long bones continues to be challenging for orthopaedic surgeon and the treatment option ranges from external fixators, nailing, ring fixators, bone grafting, soft tissue reconstruction. Limb reconstruction system (LRS) provides rigid fixation for fracture fragment and it's easy to treat soft tissue injury and it provides early mobilisation to achieve pre-injury status & activities. A prospective study of 20 cases with open fractures of lower limb long bones with age group between 20 to 60 years of both the sexes was done in Institute of Orthopaedics and traumatology, CMCH. Closed fractures and fractures treated conservatively were excluded from the study. Clinical and radiological evaluations were done at specific interval and patients were asked to weight bear to achieve early union. Function outcome was assessed by Association for the study and application of methods of Illizarov (ASAMI) criteria. The mean age of the patients in this study was 36.85 years with male predominance. Majority of the patients were injured by Road traffic accident and the mean union time of fracture was 29.2 weeks (Ranges 20- 32 weeks). Bone results as per ASAMI scoring were Excellent in 90% (18 /20), good in 5% (1 /20) and poor in 5% (1/20). Functional results as per ASAMI scoring were excellent in 80% (16/20), good in 15% (3/20) and fair in 5% (1/20). The most common mode of treatment in case of open fractures of long bone. It is definitive single stage procedure with advantage of early union with early mobilisation, simple surgical technique, easy wound management which avoids multiple surgeries and has high patient complicance.

Keywords: Open fracture, Long bone, Tibia, Femur, LRS, ASAMI criteria.

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1. Introduction

Now-a-days, due to increase in road traffic accidents, open fractures of long bones are common especially in lower limbs (femur and tibia). Open fractures are considered as surgical emergency and early intervention is needed to avoid infection rate drastically. A fracture of long bones not only leads to functional disability but also leads to economic burden in families and loss of self-esteem. These patients are treated by early administration of intravenous antibiotics, irrigation, wound debridement and usually operated several times to avoid infections and to enhance healing they might require skin grafting, muscle flap or bone grafting which in turn sometimes leads to deformity, limb length discrepancies, disuse atrophy, osteoporosis and joint stiffness because of prolonged immobilisation, hence open fractures are still challenging to manage. Limb reconstruction system is a unilateral rail system, which consists of shanz pins, rail rod and sliding clamps. LRS fixators is a better option to treat open fractures because it promotes soft tissue healing, preserve long bone vascularity, accessibility to wound, early mobilisation which reduces emotional and economical burden and enhance fracture healing by compression and distraction osteogenesis. This study was conducted to assess the efficacy, functional outcome and complication associated with LRS fixation in open fractures of lower limb long bones.

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2. Case Report

This study was conducted in Institute of Orthopaedics and Traumatology, Coimbatore medical college hospital, over a period of 2 years from 2022 to 2024. A total of 20 patients selected from the Emergency department of Coimbatore medical college hospital with compound fractures in lower limb (**Figure 1, Figure 2, Figure 7 and Figure 8**).



Figure 1: Preoperative clinical image



Figure 2: Preoperative x-rays

2.1. Inclusion criteria

- 1. Age between 20 to 60 years of both the sex,
- 2. Patients with compound fractures- Gustilo Anderson Type II, III A & B,
- 3. Individuals without psychiatric illness.

2.2. Exclusion criteria

- 1. Closed fractures and fractures which can be treated conservatively,
- 2. Pathological fractures,
- 3. Compound fractures Type IIIC,
- 4. Bed ridden patients
- 5. Patients with Psychiatric illness.

2.3. Operative procedure

Once patient is haemodynamically stabilised after doing primary survey and ruling out any immediate life-threatening conditions, patients were administered with prophylactic intravenous antibiotics, tetanus toxoid and tetanus immunoglobulins. All the patients were subjected to routine radiological & blood investigation and under spinal or general anaesthesia thorough wound debridement and thorough lavage with large amount of normal saline was given for site of open fracture and for inserting Shanz's pin stab incision was made and blunt dissection was done until the bone is reached and 3 x 6mm Shanz's pin is inserted proximal and 3 pins inserted distally with distance of 2.5cm from fracture site, after achieving the reduction with gentle manipulation, clamps and rails were connected and tightened (Figure 3, Figure 9). For tibia LRS frame is applied in anteromedial aspect (Figure 5) and for femur LRS frame is applied on lateral side of thigh (Figure 11), wound was managed with regular dressing, delayed primary closure, secondary closure, split skin graft and to heal by secondary intention depending on wound status. Post-operatively patients were administered with intravenous antibiotics and analgesics, quadriceps strengthening exercise, knee and ankle range of motion exercise were encouraged from 1st & 2nd post operative day, immediate weight bearing was advised in case of fractures without bone loss, in case of bone loss compression & distraction technique was used at t

he rate of 1mm/day started after 2 weeks postoperatively, patients and their relatives were taught to use compression and distraction unit, and weight bearing with support was started once radiological signs of union starts.



Figure 3: Post-operative x-rays



Figure 4: Follow up x-rays





2.4. Follow up

Regular follow up at the interval of 1 month was maintained till radiological signs of fracture union and there after followed by once in two months interval (**Figure 4, Figure 10**). Clinical assessment includes 1) presence or absence of pain, 2) pin site infection and loosening 3) deformities 4) joint stiffness 5) Limb length discrepancy 6) wound status. Final functional outcome was assessed using Association for the study and application of the method of Ilizarov (ASAMI Score) criteria. LRS fixator was removed in average of 8-9 months (**Figure 6, Figure 12**) and after removal of LRS, limb was immobilised with patellar tendon bearing cast or above knee cast for 3 weeks.



Figure 6: X-rays and clinical images after LRS removal



Figure 7: Pre-operative clinical images



Figure 8: Pre-operative x-rays



Figure 9: Post-operative x-rays



Figure 10: Follow up x-rays



Figure 11: Follow clinical image



Figure 12: X-rays after LRS removal

3. Review of Literature

- Vijay C et al. from India, during 2007-2010 conducted a prospective study on 45 cases of open fracture of tibia type IIIA & B managed with LRS fixator, in his study he assessed the cases using modified Andersons and Hutchins criteria and 90% of fractures united well and 72% of cases gives excellent to good result and moderate & poor results were seen in 18% & 10% respectively, he concluded that LRS fixator usage in open fracture tibia found to be simple, effective, enables fracture union, soft tissue care and allows to return to their day-to-day life activity early.¹
- 2. Ajmera et al. from India, during 2009-2012 conducted a study on outcome of LRS in open tibia diaphyseal fractures, in his study functional assessment was done using ASAMI criteria. ASAMI scoring gives excellent results in 76% and good results in 2%, fair & poor results in 4% & 8% respectively, he concluded that LRS is a definite mode of fixation for compound tibia fractures in terms of early union, minimal invasive, easy fixation, and patient compliance will be high and attaining limb length using osteogenesis.²
- 3. Kale AB et al. from India, during 2010-2013 conducted a prospective study on 30 cases with open long bone fracture fixed with limb reconstruction system, in his study results were assessed using modified Anderson and Hutchinson's criteria and gives good result in 24 cases and moderate in 5 cases & poor result in 1 patient, in his study he concluded that LRS is definite single stage procedure for open long bone fractures.³
- 4. CP Pal et al. from India, during 2012-2014 conducted a prospective study on open tibial shaft fractures managed with Ilizarov ring fixator and limb reconstruction system, functional and radiological outcome were assessed using ASAMI scoring and

concluded that LRS fixator gives better results than Ilizarov fixators in terms of soft tissue care, allows limb lengthening and early fracture union.⁴

- 5. Tekin AC et al. from Turkey, during 2015 conducted a study on outcome of type III open tibial diaphyseal fractures managed with limb reconstruction system, in his study he stats that using LRS he achieved 96% of full bony union with mean of 20.4 weeks and mean time of external fixator usage was 20 weeks and concluded that LRS will be a safe and single staged definitive procedure for open tibial diaphyseal fractures.⁵
- 6. Patil MY et al. from India, during 2015 conducted a prospective study on 54 cases of type IIIA & B managed with limb reconstruction system as a definitive management, in his study according to ASAMI score excellent results were seen in 36 cases and good results in 14 cases and 4 cases shows fair & poor results, the average fracture union was 8 months and average time to return to their work postoperatively was 20 days and he concluded that LRS is definitive, simple & easy technique which allows immediate weight bearing and excellent patient compliance.⁶
- 7. Mohammed WFF et al. from Egypt, during 2010-2016 conducted a study on 21 cases with comminuted femur fractures with bone loss fixed with limb reconstruction system, in his study he concluded that LRS is a effective and reliable mode of fixation for comminuted femur fractures with bone loss, which allows acute compression and distraction technique and shorten the duration of treatment and limit the rate of complication.⁷
- 8. H J Mangukiya et al. from India, during 2014-2016 conducted a prospective study on 40 cases with compound diaphyseal fracture fixed with limb reconstruction system and AO monolateral fixator, in his study results were assessed with ASAMI scoring system and in group I (AO monolateral fixator) shows excellent result in 30% of cases and good result in 25% of cases and poor result in 45% of cases and in group II (LRS) 60% shows excellent results and 20% with good and 10% has fair outcome and he concluded that LRS fixation is better than AO monolateral fixator in terms of easy & strong fixation, early weight bearing and early bony union and less fixators related complications.⁸
- 9. Ramesh et al. from India, during 2014-2019 conducted a prospective study on 20 cases with infected non union long bones fracture treated by distraction osteogenesis using LRS, in his study he concluded that LRS technique saves the limb which is in risk of amputation.⁹

- 10. Shady S et al. from Egypt, during 2020 conducted a study on management of open tibial fractures type IIIB by segment transfer using limb reconstruction system fixator, in his study he achieved full union in all cases and iliac bone graft at docking site was needed in 5 cases and he concluded that LRS offers a definitive mode of fixation for open tibial fractures with massive bone loss & soft tissue damage and it allows early patient mobilisation and provides enough space for repair of soft tissue damage.¹⁰
- 11. Singh P et al. from India, during 2020 conducted a prospective study in 20 patients with compound tibia fractures manages with limb reconstruction system, in his study ASAMI score for bone union was excellent in 65% of cases and good results in 25% of cases, 5% of cases shows fair and poor results respectively and functional outcome was excellent in 70% of cases and good in 20% of cases and 5% of cases shows fair and poor results, he concluded that LRS is as alternative way of management of compound tibia fractures because of easy fixation, light weight, adjustable geometry, cost-effective, good patient compliance and enhance fracture healing by compression and distraction osteogenesis.¹¹
- 12. Chahar HS et al. from India, during 2021 conducted a prospective study on evaluation of role of LRS in open fractures and infected non-union femur, in his study according to ASAMI scoring system 87.72% of cases shows excellent result and 7.14% showed good results and 7.14% shows poor results and average time taken to remove LRS fixator was 4-24 months and he concluded that LRS is simple and effective mode of fixation for open fractures which helps in early fracture union, early rehabilitation, easy care for soft tissue damage with bone loss which avoids multiple surgeries.¹²
- 13. Ravishankar et al. from India, during 2022 conducted a study on functional and radiological outcome of primary fixation of open tibial fractures with LRS and antibiotics beads, in his study he concluded that LRS provide definite and rigid fixation of fracture fragment and allows aseptic fracture union and patient can be mobile throughout treatment course without requiring another surgery and with ASAMI score 60% shows excellent and 30% shows good and 10% fair and no poor outcome were observed.¹³
- 14. Uikey et al. from Indian, during 2022 conducted a prospective study on 26 cases of complicated lower limb trauma managed with limb reconstruction system, in his study according to ASAMI score excellent results were seen in 73% and 19% shows good with 4% of cases shows fair and poor results, functional results were excellent in 84.7% and good

results in 11.5% cases and fair in 3.8% cases, he concluded that LRS is an definitive and effective modality of treatment in complicated lower limb fractures which allows early weight bearing and easy wound management and simultaneously helps in lengthening/transportation & deformity correction.¹⁴

3.1. ASAMI scoring system

ASAMI scoring system is based on Radiological and functional results.

3.1.1 Radiological results

- 1. Excellent: Union, no infection, limb length discrepancy <2.5cm, deformity <7°.
- 2. Good: Union plus any two of the above criteria.
- 3. Fair: Union plus any one of the above criteria.
- 4. Poor: Non-union or re-fracture.

3.1.2. Functional results- 5 criteria

- Presence of limp, 2) Stiffness of knee or the ankle, 3) Pain, 4) Soft tissue sympathetic dysfunction, 5) Ability to perform previous activities of daily living.
- 1. Excellent: Active, no limp, minimum stiffness, no reflex sympathetic dystrophy, insignificant pain.
- Good: Active with one or two of the following- 1) limp, 2) stiffness, 3) reflex sympathetic dystrophy, 4) significant pain.
- Fair: Active with three or all of the following- 1) limp,
 2) stiffness, 3) reflex sympathetic dystrophy, 4) significant pain.
- 4. Poor: Inactive- inability to return to daily activity due to injury or unemployment.
- 5. Failure: Amputation.

4. Result

A 20 cases of compound fracture in lower limb have been treated with LRS fixator in the Institute of Orthopaedics and Traumatology, Coimbatore medical college hospital (Table 5). The radiological and functional outcome was evaluated using ASAMI scoring system at the interval of 1 month till radiological signs of fracture union and thereafter followed by 2 monthly intervals. The results were classified as excellent, good, fair and poor. Postoperatively quadriceps, hamstring strengthening exercise, knee and ankle mobilisation exercise were started in 1st -2nd post op day, immediate weight bearing was started in transverse fractures (5 cases) and for comminuted, oblique & spiral fractures partial weight bearing was allowed in 1st week (13 cases) and full weight bearing was started within 3 weeks post operatively, partial weight bearing could not be done in 2 cases due to associated others fractures in opposite limb. Satisfactory fracture union was evaluated by signs of bridging callus in radiography, which occurred in all the cases at 3-12 months, but maximum union was achieved in 5-8months (Table 2). Excellent radiological results were

present in 18 cases, good results in 1 case and poor result in 1 case (**Table 3**). Excellent functional results were observed in 16 cases, good and fair results in 4 cases (**Table 4**). Most common complication encountered was pin tract infection in 3 cases, which is managed by wound swab for culture and sensitivity and started on appropriate antibiotics and daily dressing, other complication encountered was pin loosening for which LRS realignment done.

Table	1:	Details	of	patients
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S. No.	Variables	No. of Patients
1.	Age	
	20-29	5
	30-39	9
	40-49	4
	50-60	2
2.	Sex	
	Male	16
	Female	4
3.	Mechanism of Injury	
	Road traffic accident	18
	Fall from height	2
4.	Type of fracture	
	Grade II	2
	Grade III A	9
	Grade III B	9

Table 2: Rate of union

Union Period	Number of Cases	Percentage		
3-4 month	2	10%		
5-8 month	14	70%		
9-12 month	4	20%		
Total	20	100%		

Table	3:	Radio	logical	result
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Bone Result	Number of Cases	Percentage
Excellent	18	90%
Good	1	5%
Fair	-	-
Poor	1	5%
Total	20	100%

Table 4: Functional result

Functional	Number of Cases	Percentage		
Result				
Excellent	16	80%		
Good	3	15%		
Fair	1	5%		
Poor	-	-		
Failure	-			
Total	20	100%		

Table 5: Master chart

S.	Name	Age	Sex	Mode of	Type of fracture	Side of	Femur/	Bony union
No.				injury	(Gustilo	Injury	Tibia	In weeks
					Anderson)			
1.	Vamsi	24	Male	RTA	Grade IIIA	Right	Tibia	16
2.	Naveen	30	Male	RTA	Grade IIIB	Right	Tibia	20
3.	Karthick	30	Male	RTA	Grade IIIB	Left	Femur	32
4.	David	34	Male	RTA	Grade IIIA	Left	Tibia	24
5.	Chellapa	60	Male	Fall from	Grade IIIB	Left	Tibia	32
				height				
6.	Ganesh	28	Male	RTA	Grade IIIB	Left	Femur	44
7.	Chitra	59	Female	RTA	Grade IIIA	Right	Tibia	32
8.	Ravichandran	36	Male	RTA	Grade IIIB	Right	Tibia	28
9.	Jayaprakash	32	Male	RTA	Grade IIIA	Right	Tibia	16
10.	Thangaraj	48	Male	RTA	Grade IIIA	Right	Femur	40
11.	Kandayani	37	Female	RTA	Grade IIIB	Left	Tibia	28
12.	Kiyasudeen	38	Male	Fall from	Grade IIIA	Right	Femur	36
				height				
13.	Sanjay	26	Male	RTA	Grade II	Left	Femur	32
14.	Murugan	44	Male	RTA	Grade IIIB	Left	Tibia	32
15.	Saroja	35	Female	RTA	Grade IIIA	Right	Tibia	24
16.	Rajan	47	Male	RTA	Grade IIIA	Right	Femur	32
17.	Kuppusamy	31	Male	RTA	Grade IIIB	Left	Tibia	24
18.	Priya	25	Female	RTA	Grade II	Right	Tibia	28
19.	John Sasikumar	37	Male	RTA	Grade IIIB	Left	Femur	40
20.	Balamurugan	42	Male	RTA	Grade IIIA	Left	Tibia	24

5. Discussion

Compound fractures of lower limb are very common in developing countries due to high velocity road traffic accidents, compound fracture are surgical emergencies which should be treated as early to save the life, limb and avoid infection. According to H J Mangukiya et al. treatment of grade III compound fracture with intramedullary nailing was risky as it leads to infection and non union.¹³ Hence LRS fixators are preferred modality as it is easy to use and gives easy access for soft tissue injury postoperatively. LRS fixators provides immediate stability to fracture fragments and it allows immediate weight bearing post operatively when there is no bone loss, which provides early fracture healing and reduces financial burden for family. In this study, age of patients was ranging from 20 to 60 years with commoner age group ranging from 25 to 45 years with male predominance (Table 1). Road traffic accident was the major cause of injury and it accounts for 90% of total cases (Table 1), study conducted by Chahar HS et al. 85.72% of patients with compound fractures are caused by road traffic accidents,⁶ whereas in H J Mangukiya et al. study 72.5% cases had road traffic accident and 27.5% of cases are fall from height.¹³ In this study, maximum number of cases were belongs to Gustilo Anderson grade IIIA 9 cases (45%) and Grade IIIB 9 cases (45%)(Table 1), while in study conducted by Singh P et al. 35% of patients were type II and rest 40% patients belongs to type IIIA.² The common complication encountered was pin tract infection in 3 cases (15%) which healed on suitable parenteral antibiotics after culture and sensitivity, which is comparable to study conducted by Chahar HS et al. in which pin tract infection was 14.29%,⁶ whereas in study conducted by Gopal et al. pin tract infection was seen in 53% of cases¹⁶ and in this study there was no pin breakage. In this study excellent radiological bone result were obtained in 90% of cases and 5% showed good and 5% of cases shows poor results (Table 3) and excellent functional results were obtained in 80% of cases and 15% of cases shows good result and 5% shows fair results (Table 4). In a study conducted by Chahar HS et al. compound fractures and infected non-union of femur treated by LRS, bone result was excellent in 85.72% of cases and 7.14% shows good and 7.14% shows fair results and function result were excellent in 71.43% of cases and good & fair results were seen in 28.57% of cases.⁶ In this study there were no shortening of limb at final follow up, according to Marsh et al. compound supracondylar femur fracture treated with external fixators shows shortening and malignant in 30.76% cases¹⁵ and study conducted by Ramesh et al. limb length discrepancy was seen in 15% of cases.¹⁴ LRS fixators are light weight, patients friendly and day to day activities can be done easily and its uniplanar frame allows early mobilisation of joints, early weight bearing, and it gives easy access for soft tissue repairing procedures. These fixators can be reused for another patient with proper handling and autoclaving. In this study compound fractures of lower limb treated by limb

reconstruction system- radiological result were excellent in 90% and function result were excellent in 80% of cases. Main disadvantage is that it could not correct angulations or rotational deformity.

6. Conclusion

Limb reconstruction system is a simple and easy technique which is used as primary and definitive single stage fixation for compound fracture of lower limb due to its strong fixation, early weight bearing & early bone union and easy access for soft tissue care. It reduces hospital stay, financial burden and patient compliance is excellent, implant can be reused hence it is cost effective.

7. Source of Funding

None.

8. Conflict of Interest

None.

9. Ethical

ECR/892/Inst/TN/2016.

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