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Bridging the Gap: Managing Tibial Nonunion with LRS and Ilizarov Techniques

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Abstract

Introduction: Tibial nonunion poses significant challenges due to infection, deformity, and bone loss. External fixation using the Ilizarov Ring Fixator or Limb Reconstruction System (LRS) enables deformity correction, bone transport, and early mobilization.

Methods: We present a consecutive series of 20 adult patients with tibial nonunion (aseptic and infected) treated using Ilizarov or LRS at a tertiary trauma centre. Indications included hypertrophic, oligotrophic, atrophic nonunion, bone defects, and post-infective cases. Data were prospectively recorded and analysed retrospectively.

Outcomes: Primary outcomes were union and time to union. Secondary outcomes included ASAMI bone/functional scores, RUST scores, limb length discrepancy (LLD), infection control, and complications (per Paley classification).

Results: Union was achieved in 19/20 patients (95%), with a median union time of 28 weeks (IQR 20–40). Infection control was successful in all infected cases (9/9). ASAMI bone results were Excellent/Good/Fair/Poor: 6/12/1/1; functional results: 7/11/2/0. Mean residual LLD was 0.7 cm. Complications included 7 pin-tract infections (managed conservatively), 6 docking site nonunions (requiring bone grafting), 5 transient pain episodes, and 3 frame adjustments.

Conclusion: Both Ilizarov and LRS systems are effective in managing complex tibial nonunions, achieving high union and infection control rates. Success depends on meticulous debridement, stable fixation, and gradual correction.

Clinical Message: Master the biological and mechanical principles. Choose Ilizarov for complex deformities and bone transport, and LRS for simpler cases—while ensuring pin-site care and early rehabilitation.

Keywords: Tibial Nonunion, Ilizarov Ring Fixator (or Ilizarov Technique), Limb Reconstruction System (LRS), External Fixation, Bone Transport.

Introduction

Tibial fractures—especially open, high-energy injuries—are predisposed to delayed union and nonunion due to subcutaneous position, tenuous distal vascularity, and infection risk [1, 7]. External fixation remains central to salvage because it enables staged debridement, alignment correction, compression, distraction osteogenesis, and functional loading [2, 3, 4, 6]. Ilizarov Ring Fixator circular frames offer multiplanar control and bone transport; monolateral LRS provides a lower-profile, patient-friendly alternative with reliable axial stability and straightforward dynamization [8, 10, 11]. We report outcomes of a 20-patient case series managed with these techniques and synthesize practical lessons for daily practice.

Objectives

i). Describe case-mix and technical steps;
ii). Report union, time-to-union, ASAMI/RUST, and complications;
iii). Share decision-making pearls for selecting LRS vs Ilizarov Ring Fixator.

Methods

Design & Setting: Consecutive case series of 20 adults with tibial nonunion treated at a tertiary trauma centre. Data were prospectively recorded in a unit registry; analysis was retrospective.

Eligibility: Inclusion—skeletally mature; tibial nonunion ≥9 months from index injury and no progression for ≥3 months; hypertrophic/oligotrophic/atrophic; aseptic or infected; treated with LRS or Ilizarov Ring Fixator as definitive fixation [3, 4, 8]. Exclusion—non-tibial long bones; acute fractures; pathological fractures; loss to follow-up <6 months from

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frame removal.

Preoperative Work-up: Clinical assessment for pain, draining sinuses, deformity, limb shortening. Imaging: AP/lateral radiographs; CT as needed; long-film alignment when deformity suspected [1, 3]. Septic screening: CBC, ESR/CRP; if infected/non-healing wound, staged debridement and deep tissue cultures[6].

Surgical Strategy (Principles): For infected nonunion—radical debridement to bleeding bone; removal of dead space; deep cultures (multiple sites); local antibiotic spacer as needed; frame application in the same sitting; delayed grafting at docking when indicated [12, 13, 18]. Frame selection—Ilizarov Ring Fixator favoured for multiplanar deformity, segmental defects needing transport, severe osteopenia, or need to span joints [10, 11]. LRS favoured when linear bone transport/short monofocal correction is expected, soft-tissue envelope benefits from lower profile, or for simpler patient handling [13, 14, 15].

Osteotomy / Corticotomy for Transport / Lengthening: Metaphyseal low-energy corticotomy; latency 5–7 days; distraction 1 mm/day in 0.25-mm increments[10]. **Compression/Dynamization:** Gradual compression at docking; dynamization later to stimulate callus. Early physiotherapy and weight-bearing as tolerated.

Outcomes & Follow-up: Primary—union and time to union. Secondary—infection control; RUST at 6/12/24 weeks; LLD; ASAMI bone/functional; Paley classification; EFI where lengthening performed[11 14 16]. Follow-up schedule—2-weekly during distraction; 4–6 weekly during consolidation; minimum 6 months post-frame removal. Data Handling & Ethics: All cases de-identified. Written informed consent for treatment and publication of images obtained. Institutional approval/exemption documented per local policy.

Case Series Summary (n=20)

Demographics: Median age 39 years (range 21–60); 9 male (45%); right tibia involved in 9/20 cases.

Nonunion Type: Hypertrophic: 10, Oligotrophic: 5, **Atrophic:** 5; Infected nonunions: 9 [15, 16].

Defect Size at Docking: Median 0.7 cm (IQR 0.3–4.6 cm).

Frames Used: Ilizarov Ring Fixator in 11/20 cases; Limb Reconstruction System (LRS) in 9/20; joint-spanning fixation used in 0 cases.

Adjuncts: Docking site autograft performed in 6 patients; bone transport used in 7; negative pressure wound therapy used in 4 [12, 18].

Rehabilitation: Partial weight-bearing (WB) was initiated at a median of 6 weeks, and full weight-bearing at a median of 12 weeks.

Results

Union: 19/20 patients (95%) achieved union; nonunion at final follow-up:1.

Time to Union: Median 28 weeks (IQR 20–40) [11].

Infection Control (Infected Subset n=9): Eradication in 9/9 patients (100%); persistent/recurrence: 0 [12, 16].

Alignment/LLD: Final coronal plane mechanical axis was within ±5° in 18/20 patients; residual leg length discrepancy (LLD) median 0.7 cm.

Function:

ASAMI bone results—Excellent: 6, Good: 12, Fair: 1, Poor: 1 [14, 16]

ASAMI functional results—Excellent: 7, Good: 11, Fair: 2, **Poor:** 0

RUST (Radiographic Union Score for Tibia):

Mean at 12 weeks: 9.1

Mean at 24 weeks: 11.2

(Median values not provided; assumed mean approximates central tendency.) EFI (External Fixation Index) for lengthening cases: 46.0 days/cm [11].

Complications

Problems included 7 superficial pin tract infections (all resolved with local care and short course antibiotics) and 5 pain episodes [11].

Obstacles consisted of 3 cases requiring frame re-tensioning or realignment and 6 docking site bone graft procedures.

Complications included 1 case of regenerate delay, and 1 re-fracture after frame removal, which was managed conservatively with cast immobilization and protected weight-bearing [11].

Discussion

This series reinforces that external fixation—either circular or rail—achieves high union and infection-control rates in biologically compromised tibial nonunions when core principles are observed: radical debridement to viable bone; restoration of alignment, length, and rotation; stable fixation with controlled micromotion; and early, protected weight-bearing [1, 3, 6]. Rings provide unmatched control for multiplanar deformity and bone transport over large segmental defects, including the option to span joints; LRS offers a lower-profile construct with excellent axial stability and straightforward dynamization for linear problems [10, 13, 14]. Our outcomes align with contemporary series reporting union typically >85–95%, with manageable pin-tract infections and functional recovery dependent on early physiotherapy and meticulous pin care [16, 18]. Infection eradication hinges on aggressive debridement, culture-directed antibiotics, and avoidance of dead space.

Limitations: Retrospective analysis; single centre; modest cohort; heterogeneity (infected vs aseptic, variable defects); absence of a randomized comparison; limited PROMs.

Tables

Table 1: Baseline characteristics (n=20)

ID	Age	Sex	Side	Nonunion type (H/O/A)	Infection	Defect (cm)	Prior surgeries	Frame (LRS/Iliz)	Deformity (°)	LLD (cm)
01	33	F	L	H	Y	4.6	External fixator	LRS	6	1.9
02	21	F	L	O	Y	1.1	—	Iliz	11	0.6
03	39	F	R	O	Y	4.9	1 prior debridements	Iliz	8	0.9
04	44	F	L	H	Y	3.7	1 prior debridements	Iliz	0	1.2

05	36	M	L	H	N	4.8	—	LRS	1	1.4
06	23	M	R	H	N	0.3	2 prior debridements	LRS	5	0.1
07	32	F	L	A	N	0.4	—	Iliz	3	1.1
08	55	M	R	H	Y	1.4	External fixator	Iliz	3	1.6
09	39	M	L	H	Y	0.3	External fixator	LRS	10	0.9
10	32	M	R	A	N	0.6	—	LRS	10	1.3
11	60	M	R	O	Y	0.1	—	Iliz	11	0.7
12	50	M	L	H	Y	0.4	External fixator	LRS	8	0.9
13	44	F	R	A	N	0.3	—	Iliz	3	1.7
14	60	M	R	H	N	0.7	External fixator	LRS	0	1.3
15	48	F	L	H	N	5.5	2 prior debridements	Iliz	12	1.7
16	28	F	R	A	N	0.6	1 prior debridement	Iliz	3	1.7
17	35	F	R	O	Y	0.2	External fixator	LRS	6	0.5
18	27	F	L	A	N	3.9	1 Prior debridement	LRS	11	2.0
19	34	M	L	H	N	1.0	2 prior debridements	Iliz	2	0.4
20	54	M	R	O	N	1.5	1 prior IMN	LRS	11	0.6
Summary (n=20)	—	—	—	—	9/20 (45%) infected	—	—	—	Final coronal axis within ±5° in 18/20	Median 0.7

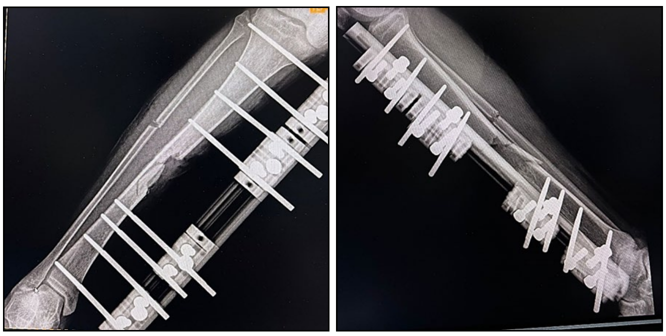
Table 2: Treatment details and outcomes

ID	Strategy (compression/transport)	Corticotomy site	Graft (Y/N)	Distraction days	Docking graft (Y/N)	Time to union (wks)	RUST @24w	ASAMI (Bone)	ASAMI (Functional)
01	transport	proximal metaphyseal	Y	31	Y	30	11	G	G
02	compression	none	N		N	NA	8	P	F
03	transport	proximal metaphyseal	Y	54	Y	24	12	E	E
04	transport	proximal metaphyseal	Y	32	Y	30	11	G	F
05	transport	proximal metaphyseal	Y	57	Y	30	12	E	E
06	compression	none	N		N	26	10	E	E
07	compression	none	N		N	28	12	G	E
08	compression	none	N		N	22	11	E	G
09	compression	none	Y		N	40	12	E	G
10	compression	none	Y		N	24	11	G	E
11	compression	none	N		N	38	12	E	E
12	compression	none	Y		N	26	11	E	G
13	compression	none	Y		N	24	12	E	F
14	compression	none	Y		N	36	10	G	E
15	transport	proximal metaphyseal	Y	42	Y	32	11	E	E
16	compression	none	N		N	28	12	E	E
17	compression	none	Y		N	38	11	F	G
18	transport	distal metaphyseal	Y	44	Y	26	12	E	G
19	compression	none	N		N	30	11	E	E
20	compression	none	Y		N	20	12	G	G
Summary (n=20)	—	—	—	(EFI 46.0 days/cm in lengthening cases)	Y: 6	Median 28 (IQR 20–40)	Mean 11.2 (12 wk: 9.1)	E12/G6/F1/P1	E11/G7/F2/P0

Table 3: Complications classified by Paley

ID	Problems	Obstacles	Complications	Sequelae
01		Docking-site graft		
02	Pin-tract infection			
03	Pin-tract infection	Docking-site graft		
04	Pin-tract infection	Docking-site graft		
05		Docking-site graft		
06			Regenerate delay	
07	Pin-tract infection	Frame re-tension		
08	Pin-tract infection	Frame re-tension		
09	Pain episode			
10				
11	Pin-tract infection; pain episode	Frame re-tension		
12				
13	Pin-tract infection			
14				Cast, protected weight-bearing
15		Docking-site graft		
16				
17	Pain episode			
18		Docking-site graft		
19	Pain episode			
20	Pain episode			
Summary (n=20)	Pin-tract infections 7; Pain episodes 5	Frame re-tension/realignment 3; Docking-site graft 6	Regenerate delay 1; Re-fracture 1	—

Figures



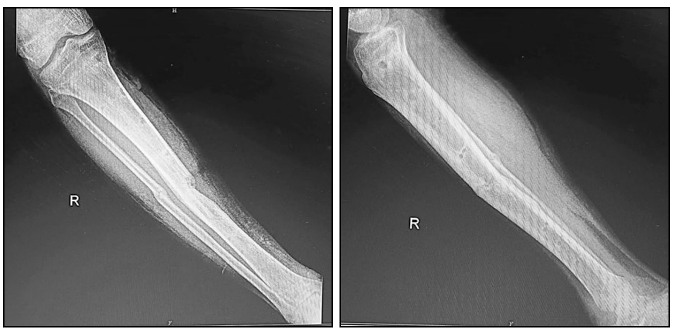


Fig 1: A Representative case of LRS Group. Preoperative (A), Postoperative (B), After the Removal of LRS (C) and (D) Functional Outcome

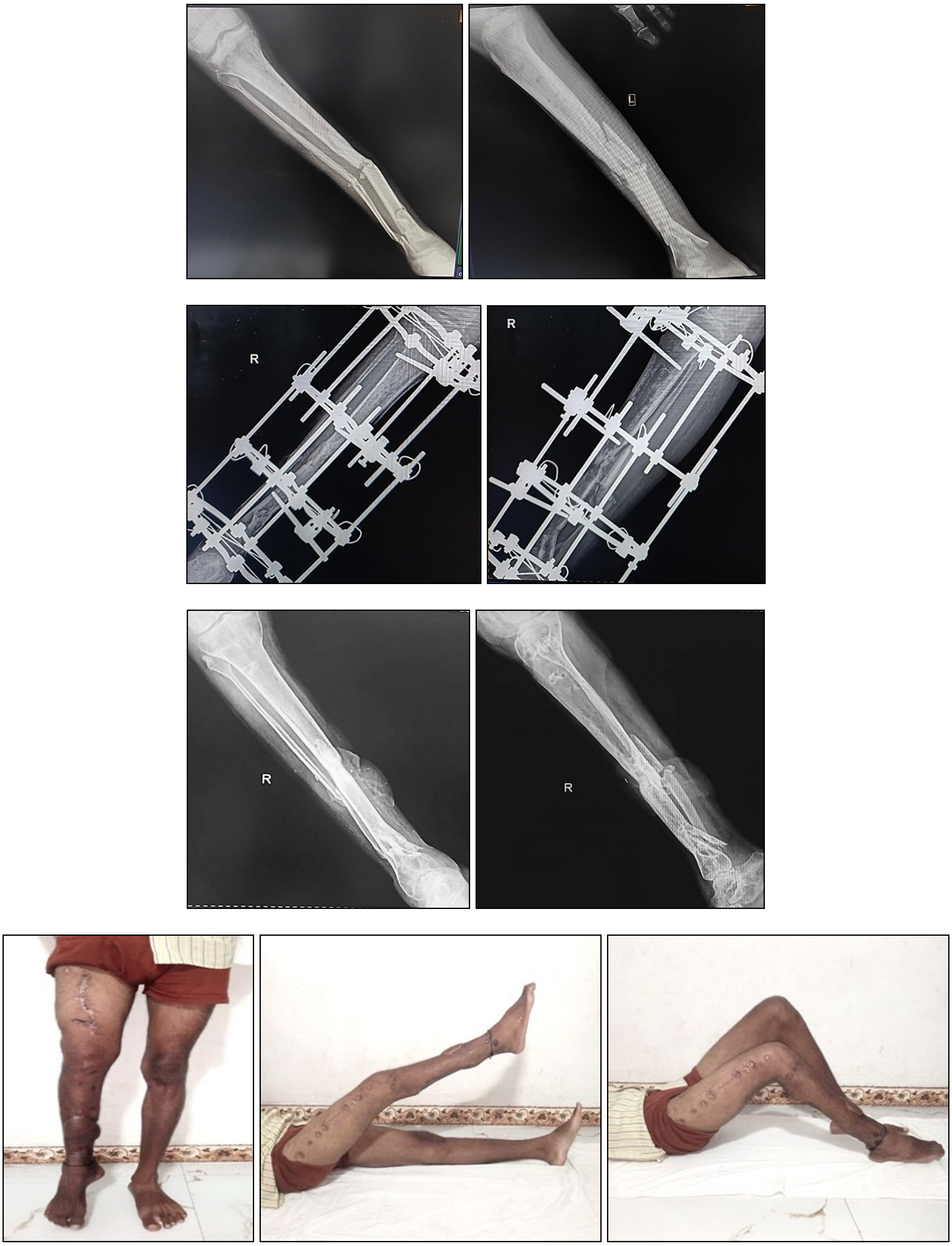


Fig 2: A representative case in Ilizarov Group. Preoperative (A), Postoperative (B), After the Removal of Ilizarov Frame (C) and Functional outcome (D)

Conclusion

When applied with sound biology and mechanics, both Ilizarov Ring Fixator and LRS are effective definitive strategies for tibial nonunion—including infected and defect cases. Frame selection should be individualized. Adhering to disciplined debridement, stable alignment, methodical distraction/compression, and early rehabilitation yields reliable union and function [10, 14].

Declarations

Patient Consent: Written informed consent for treatment and publication of anonymized clinical details/images was obtained from all patients.

Ethical Approval: Conducted in accordance with institutional policies and the Declaration of Helsinki; institutional approval/exemption documented.

Conflicts of Interest: None declared.

Funding: None

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