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Retrospective Study on the Outcome of Deformity Correction and Distraction Osteogenesis in Deformed Femur Using Orthofix-LRS

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ABSTRACT

Background: Femoral deformities, whether congenital or acquired, significantly impair mobility and quality of life. Deformity correction and distraction osteogenesis are proven techniques for limb reconstruction. The use of the Orthofix Limb Reconstruction System (LRS) offers a promising method for achieving precise deformity correction with minimal complications.

Methods: A retrospective study was conducted Dr B R Ambedkar Medical College and Hospital, in which twenty patients between Jan 2021 and May 2023, who had undergone limb lengthening and deformity correction of femur using Orthofix-LRS were included in the study and data collected after a two year follow up period included the amount of lengthening achieved and the degree of deformity corrected based on clinical measurements and radiographic assessments.

Results: The mean age was 24.43 years, with the majority in the 20–32 age group. Most patients were male (85%). The average angular deformity corrected was 21 degrees (range, 10-32) with subsequent average lengthening of 5.43 cm (range, 2.5-11.5). The average of the healing index of regenerate was 32.29days/cm (range, 26.33-71.5 days/cm). All of them needed a prolonged fixator carrier period, at an average of 59.64 days for each centimetre of lengthening. Significant complications include one broken regenerate and one lateral angulation deformity of the sub-trochanteric region.

Conclusion: The study concludes that the monolateral external fixator Orthofix-LRS can be effectively utilised in the management of limb length discrepancy with angular deformity, as it provides stable fixation for diaphyseal lengthening and correction of metaphyseal deformity.

Key-words: Deformity correction, Distraction osteogenesis, Limb lengthening, Orthofix LRS, Regenerate

INTRODUCTION

Femoral deformities can significantly impair mobility and function. Deformity and leg-length discrepancy are common complications following high-energy distal femoral fractures. Traumatic injury to the physis, congenital disorders like Osteogenesis imperfecta, metabolic disorders like Rickets are some other common conditions, which lead to the deformed and shortened femur.

Accepting these deformities leads to osteoarthritis, pain, gait abnormalities, limb length discrepancies, and psychosocial distress. and stiffness of the knee [1]. The problem is still compounded if there is an associated infection and/or non-union.

Globally, lower limb deformities affect millions, particularly in low- and middle-income countries, where access to timely orthopedic care is limited. Trauma, especially road traffic accidents, contributes significantly to post-traumatic femoral deformities, especially among the young, economically productive population [2].

Congenital conditions such as congenital femoral deficiency, proximal femoral focal deficiency, and

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developmental dysplasia of the hip are also notable causes of deformity. These deformities often require surgical intervention to restore function and alignment. Failure to treat can lead to long-term disability, compensatory pelvic tilt, scoliosis, and secondary osteoarthritis [3].

Traditionally, acute correction using open reduction and internal fixation (ORIF) with plates or intramedullary nails was used for deformity correction. However, this method is limited in complex or multiplanar deformities and carries risks like neurovascular injury, soft tissue compromise, and incomplete correction [4].

While the Ilizarov apparatus has traditionally been used, the Orthofix LRS has emerged as a user-friendly and versatile alternative, particularly for femoral applications [5]. Distraction osteogenesis using external fixators is an effective method to correct deformities and equalize limb length. The Orthofix Limb Reconstruction System (LRS) was developed as a monolateral external fixator that retains the benefits of distraction osteogenesis while simplifying the surgical technique and improving patient mobility. It allows precise correction in one or more planes, is less cumbersome than circular fixators, and permits early mobilization with better hygiene and comfort. Studies by Paley *et al*. and Catagni *et al*. demonstrated the LRS's effectiveness in limb lengthening, non-union treatment, and angular deformity correction [6,7]. Indian studies, such as those by Kulkarni *et al.* have confirmed its efficacy in treating infected non-unions and complex femoral deformities [8].

To our knowledge, there have been few reports regarding the management of these complex problems. In this retrospective study, we have analysed the results of treatment of deformed and shortened femur using monolateral Orthofix external fixator (LRS) to attain a perfectly aligned limb. In India, there is a growing need to evaluate the effectiveness of Orthofix LRS, especially in resource-limited settings. This study addresses the gap by analysing its outcomes in a tertiary care orthopedic setup.

MATERIALS AND METHODS

Place of the study- A retrospective cross-sectional study was carried out in which twenty patients between Jan 2021 and May 2023, who had undergone limb lengthening and deformity correction of femur using Orthofix (LRS), were included in the study.

Inclusion Criteria

- Patients aged more than 18 years, of both sexes
- Undergoing distraction osteogenesis using a monolateral Orthofix external fixator (LRS) for a shortened and deformed femur
- Willing to provide written informed consent

Exclusion Criteria

- Incomplete data.
- Patients treated with other/additional fixation systems
- Patients lost for follow-up

Methodology- Following approval from the Institutional Ethics Committee and obtaining informed consent, patients meeting the inclusion criteria were enrolled. Data were collected using a pre-designed questionnaire.

Preoperative planning- A thorough clinical assessment was performed to measure limb length discrepancy (LLD) and to evaluate the deformity, joint range of motion, neurovascular status, and condition of the soft tissues. Radiological evaluation included plain radiographs, and whole-limb films were obtained using the orthoroentgenogram technique. The degree of deformity was assessed using the anatomical axis of the femur, and the osteotomy line was defined along the bisector passing through the center of rotation of angulation (CORA).

Surgical Procedure outline- Under fluoroscopic guidance, Schanz pins were inserted into the proximal and distal bone segments. The Orthofix LRS rail was then connected to the Schanz pins using clamps, ensuring proper alignment and stability. A lateral closing wedge osteotomy was performed to correct the deformity, and the correction was confirmed fluoroscopically. After achieving satisfactory alignment, final tightening of the clamps and rail was carried out, and overall stability was rechecked. Trial components were subsequently inserted, and intraoperative assessment of stability and range of motion (ROM) was performed before placement of the final implants.

Postoperative protocol- Distraction at the osteotomy site was started from the 5th postoperative day using a compression–distraction unit at a rate of 0.5 mm twice daily, with weekly radiographic monitoring of regenerate

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formation. Partial weight bearing was allowed once satisfactory regenerative quality was observed. The regenerate was considered healed when its bone density matched the adjacent bone, after which full weight bearing was initiated with the addition of a Dyna ring for progressive loading. The fixator was locked during the consolidation phase and removed after the appearance of cortico-medullary differentiation.

Outcome measures- At each follow-up, the following were measured-

- Lengthening achieved.
- Degree of deformity corrected.
- Fixator period (FP): time period for which the fixator was in situ.
- Regenerate healing index (HI):

$$\text{HI} = \frac{\text{Time period from fixator application to unprotected full weight bearing (days)}}{\text{Total lengthening achieved (cm)}}$$

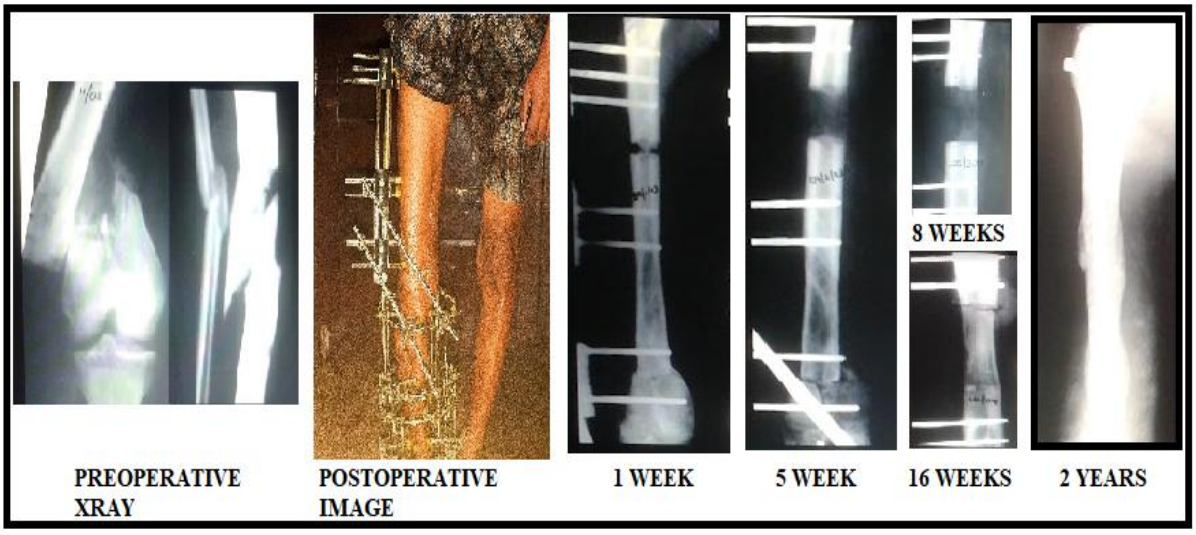

Fig. 1: A case illustration of patient follow-up, lengthening achieved: 9 cm

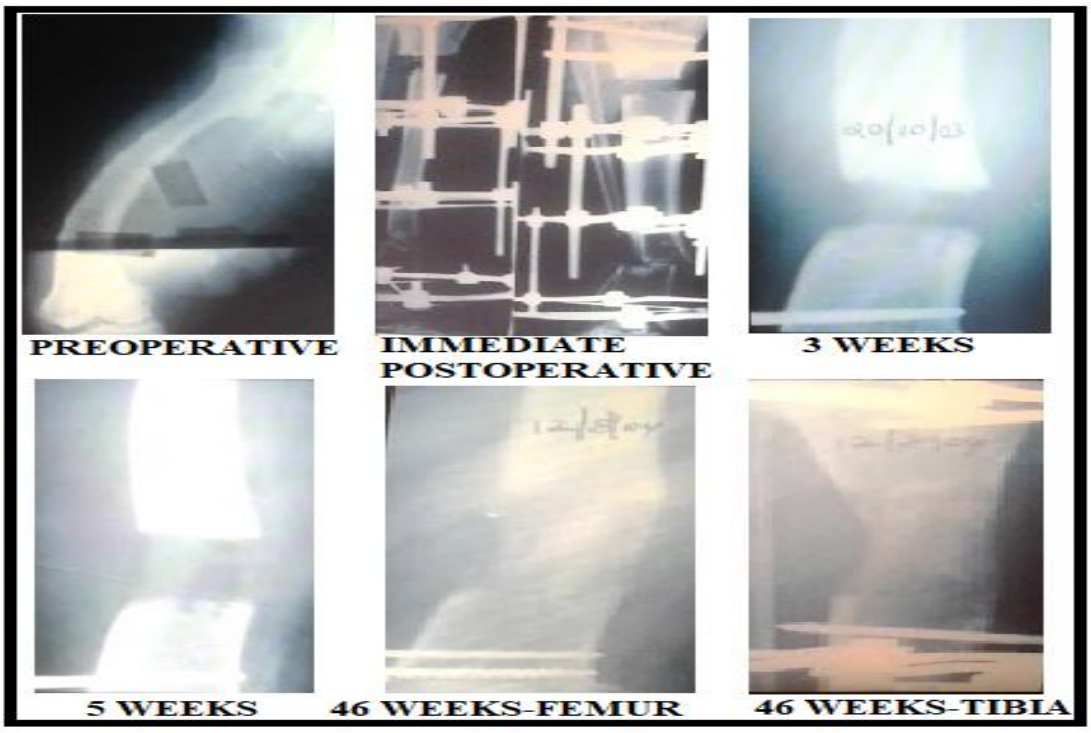

Fig. 2: A case illustration of patient follow-up, lengthening achieved: 6 cm

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Complications- Complications were classified as Class 1: No long-term functional or anatomical significance, Class 2: Correction requires anaesthesia or operation but has no long-term significance, Class 3: Significant functional or anatomical complication which improves spontaneously or is correctable by surgery, Class 4: Irremediable by conventional treatment.

Statistical Analysis- Statistical analysis was performed to assess the association between age, amount of lengthening, and healing index (H.I.). Two-tailed tests were used with a significance level of α=0.05. Associations between categorical age groups and healing index, and between amount of lengthening and healing index, were analysed using the Chi-square (χ^2) test, as the variables were categorical and observations were independent. P values were obtained from standard χ^2 distribution tables (Mahajan).

Ethical Approval- Approval for the study was obtained by the institutional ethics committee, Dr B R Ambedkar Medical College, Bengaluru, Karnataka, India, dated 20-06-2025.

RESULTS

Table 1 summarizes the individual patient outcomes at the end of the study. A total of 20 patients were analysed with a mean age of 24.45 years. The mean lengthening achieved was 5.43 cm (range, 2.5–11.5 cm). The mean total fixator period was 327.5 days (range, 140–680 days), corresponding to an average fixator period of 59.63 days per centimetre of lengthening. The mean healing index (H.I.) was 32.38 days/cm, with values ranging from 26.33 to 71.5 days/cm. Complications were observed in varying grades, with all patients experiencing at least Class 1 complications, while higher-grade complications were infrequent.

Table 1: Shows the measured outcomes at the end of the study (F. P=Fixator Period).

Case	Age	Lengthening	Total F.P.	F.P. / cm	H.I. days/cm	Complications
1	28	4.5	245	54.44	26.66	Class 1,2
2	19	9	540	60	33.33	Class 1,3
3	29	6	405	67.5	30	Class 1,2
4	24	4	215	53.75	27.75	Class 1
5	20	11.5	680	59.13	29.56	Class 1,2
6	32	4.5	235	52	28	Class 1,2,4
7	20	5	290	58	31.66	Class 1
8	20	4	230	57.5	28.4	Class 1
9	22	2.5	140	56	26.33	Class 1
10	22	4	225	56.25	28.95	Class 1
11	31	5	460	92	71.5	Class 1,2
12	24	7	440	62.85	33.23	Class 1,2
13	22	5	290	58	28.5	Class 1
14	26	4	190	47.5	29.56	Class 1,3
15	21	3	300	55.5	32.5	Class 1
16	27	2.5	320	57.5	32.34	Class 1
17	20	8	235	61.5	32.16	Class 1,2
18	29	5.5	350	69	30.86	Class 1
19	22	6	420	49	33.14	Class 1
20	31	7.5	340	58.1	33.17	Class 1
MEAN	24.45	5.425	327.5	59.63	32.38	

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The patients were further stratified into three age-based groups as shown in Table 2. In patients aged ≤20 years (Sample 1), the median lengthening was 5 cm with a median healing index of 29.6 days/cm. In the 21–25 years age group (Sample 2), the median lengthening was also 5 cm, and the median healing index was 28.95 days/cm. Patients older than 25 years (Sample 3) showed a lower median lengthening of 4.5 cm but a relatively higher and wider range of healing index values, with a median of 30.28 days/cm, indicating greater variability in bone regeneration in older patients.

Table 2: Descriptive Statistics of Study Variables [(Values expressed as Median (Range)]

Sample based on age	Number	Age (years)	Lengthening (cm)	Healing Index
Sample 1 (Age <=20)	5	20 (19–20)	5 (4–11.5)	29.6 (28.4–31.7)
Sample 2 (Age 21-25)	7	22 (22–24)	5 (4–9)	28.95 (27.75–33.33)
Sample 3 (Age>25)	8	30.5 (26–32)	4.5 (4–6)	30.28 (26.66–71.5)

Chi-square analysis results are presented in Table 3. In Samples 1 and 2, no statistically significant association was found between age and healing index ($p>0.05$). However, in Sample 3 (age>25 years), a statistically significant association between age and healing index was observed ($\chi^2=13.41$, $p=0.009$), suggesting that increasing age adversely affected the healing index. No statistically significant association was observed between the amount of lengthening and healing index in any of the three age groups ($p>0.05$), indicating that the extent of lengthening did not significantly influence regenerate healing.

Table 3: Shows Chi-Square Analysis of Age vs Healing Index and Lengthening vs Healing Index

Samples	Age vs Healing Index		Lengthening vs Healing Index	
	χ^2 value	p-value	χ^2 value	p-value
Sample 1	0.0733	0.79	1.841	0.17
Sample 2	0.4974	0.48	1.57	0.21
Sample 3	13.41	0.009	2.38	0.12

DISCUSSION

The mean lengthening achieved in our study was 5.43 cm (range, 2.5–11.5 cm), comparable to findings by Paley *et al*. and Catagni *et al.*, where average femoral lengthening ranged from 4.5 to 6.5 cm in similar cohorts [3,9]. Our results are also in alignment with Guo *et al*. [10], who reported a mean lengthening of 5.6 cm in femoral deformity correction using external fixators.

The mean deformity corrected was 21°, with full correction achieved in all patients. The use of micrometric swiveling clamps in two of our cases enabled gradual correction at the malunion site but was associated with delayed union, a pattern also noted by Laubscher *et al*. [11], who highlighted the trade-off between precision in correction and regenerate consolidation time.

The mean external fixator time was 327.5 days, translating to approximately 59.63 days per cm of lengthening. Although higher than reported in some studies (e.g., Rozbruch *et al*. [12] reported 45–50 days/cm), the increased duration may reflect the complexity of deformities, delayed union in certain cases, and cautious progression in infected non-unions. However, our bone healing index of 32.39 days/cm was within acceptable limits and comparable to El-Mowafi *et al*. [13], who reported healing indices between 30–35 days/cm in similar reconstructive protocols.

Regarding complications, all patients experienced Class 1 pin tract infections, managed effectively with first-generation cephalosporins. This mirrors the complication rates in similar studies by Feldman *et al*. [14] and Sen *et al.* [15], confirming pin tract infection as the most common

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but usually manageable issue in external fixation. One patient experienced a Class 4 complication involving regenerative bending due to inappropriate distraction by a patient with psychiatric illness. This highlights the importance of patient selection and compliance, a concern echoed by Kocaoglu *et al*. [16], who emphasized strict supervision in mentally compromised individuals undergoing limb reconstruction.

Encouragingly, all patients achieved full weight-bearing at final follow-up, with no residual pain during activities of daily living. Only one patient required a 3 cm shoe raise, and despite minor residual deformities or limp in a few cases, all individuals maintained independence in daily functioning. These outcomes align with those of Mihalko *et al*. [17] and Manner *et al.* [18], who reported high patient satisfaction and functional recovery in femoral distraction osteogenesis cases despite mild residual gait alterations.

Knee stiffness was observed in four patients, particularly among those with pre-existing joint limitations or prolonged external fixator use, with one case resulting in a stiff knee due to an infected non-union. This is a known complication associated with prolonged fixation and inadequate physiotherapy, as also reported by Rozbruch *et al.* and Liodakis *et al.*[12,19].

In summary, our study supports the efficacy of Orthofix LRS in managing femoral deformity and shortening. The correction achieved was substantial, healing indices were acceptable, and complications were within expected ranges. Importantly, all patients were able to ambulate independently at follow-up.

CONCLUSIONS

Distraction osteogenesis using the Orthofix Limb Reconstruction System (LRS) is a reliable and effective method for the correction of femoral deformity and limb length discrepancy. In our retrospective analysis, satisfactory outcomes were achieved in terms of deformity correction, lengthening, and bone healing indices. Despite a few manageable complications, all patients regained independent ambulation and functional limb use. Careful planning, patient compliance, and timely management of complications contribute significantly to successful outcomes. The Orthofix LRS provides prospects of a controlled and adaptable approach for femoral deformity correction and limb lengthening, especially in challenging cases involving malunion, shortening, or infection. Future studies with larger cohorts and prospective designs may help further optimize protocols to reduce fixator time and improve joint mobility outcomes.

CONTRIBUTION OF AUTHORS

Research concept- Dr Anil Kumar S V
Research design- Dr Anil Kumar S V
Supervision- Dr Anil Kumar S V
Materials- Dr Anil Kumar S V
Data collection- Dr Anil Kumar S V, Dr Arun Kumar R
Data analysis and interpretation- Dr Anil Kumar S V, Dr Arun Kumar R
Literature search- Dr Anil Kumar S V, Dr Arun Kumar R
Writing article- Dr Anil Kumar S V, Dr Arun Kumar R
Critical review- Dr Anil Kumar S V, Dr Arun Kumar R
Article editing- Dr Arun Kumar R
Final approval- Dr Anil Kumar S V

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