IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 25, Issue 5 Ser. 1 (May. 2026), PP 73-85
www.iosrjournals.org

Correction of Deformity Around the Knee Joint by Ilizarov Method

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Abstract

Background: *Deformities around the knee joint result in altered biomechanics, impaired function and joint degeneration. The management of complex deformities remains challenging, particularly in long-standing cases with soft tissue contractures and limb-length discrepancies. This study aimed to evaluate the clinical, functional and radiological outcomes of knee deformity correction by using the Ilizarov method.*

Methods: *This cross-sectional observational study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh and a private hospital in Dhaka, Bangladesh, from January 2018 to December 2024. Twenty-five patients with knee joint deformities underwent gradual correction using the Ilizarov technique. Demographic data, operative parameters, functional scores and radiological measurements were collected. Outcomes were assessed preoperatively and at the one-year follow-up.*

Results: *A total of 25 patients were included in this study. The mean age was 28.4 ± 8.2 years with predominantly male 16 (64.0%). Post-traumatic deformity was the most common cause (48.0%), followed by post-septic (32.0%) and congenital (20.0%) causes. Regarding the deformity site, 30 segments (tibia/fibula) were involved. In the frontal plane, varus deformity was observed in 15 (60.0 %) patients and valgus deformity in 7 (28.0 %) patients. In the sagittal plane, procurvatum was observed in four patients (16.0%) and recurvatum in two (8.0%). The mechanical axis deviation improved from 28.4 ± 6.1 mm preoperatively to 4.2 ± 3.7 mm postoperatively ($P < 0.001$). The knee range of motion increased from 64.8 ± 18.2° to 112.3 ± 16.7° ($p < 0.001$) and the Knee Society Score improved from 48.6 ± 10.4 to 86.2 ± 9.8 ($p < 0.001$). The limb-length discrepancy was reduced from 15.3 ± 5.9 mm to 4.6 ± 3.2 mm ($p = 0.002$). The mean radiological union time was 21.4 ± 3.8 weeks. Residual deformity was noted in five patients (20.0%) at the one-year follow-up. Joint stiffness (>20° residual flexion) was observed in 14 patients (56.0%). The most common complication was superficial pin-tract infection (20.0%).*

Conclusion: *The Ilizarov method provides effective, accurate and functional correction of deformities around the knee joint.*

Keywords: *Knee deformity, Ilizarov technique, external fixation, limb alignment, functional outcome, MAD.*

I. Introduction

Deformities around the knee joint represent a challenging clinical entity due to their complex biomechanical implications and significant impact on lower limb function. Malalignment at the knee alters load distribution across the joint, accelerates degenerative changes and compromises gait efficiency, ultimately affecting quality of life [1,2]. Common etiologies include post-traumatic sequelae, post-infectious growth disturbances and congenital conditions, all of which may lead to multiplanar deformities accompanied by limb length discrepancy and restricted range of motion [3,4].

Conventional corrective strategies, such as acute osteotomy with internal fixation, may be limited in cases of severe or long-standing deformity, particularly when gradual correction, soft-tissue adaptation, or limb length restoration is required [5,6]. High tibial osteotomy has been widely employed for coronal plane/frontal plane deformities; however, its applicability diminishes in complex, multiplanar, or stiff deformities, where precise correction and postoperative adjustability are critical [7,8]. Moreover, acute correction carries a risk of neurovascular compromise, joint instability and residual malalignment [9].

The Ilizarov method, based on the principle of distraction osteogenesis, offers a versatile alternative for managing complex knee deformities. Its modular external fixation system allows gradual, controlled correction of angular, translational and rotational deformities while simultaneously addressing limb length discrepancy [10,11]. Additionally, the technique facilitates progressive soft-tissue stretching, reducing the risk of neurovascular injury and enabling correction even in rigid or neglected deformities [12,13].

Previous studies have demonstrated favorable outcomes with the Ilizarov technique in deformity correction around the knee, reporting improved alignment, enhanced joint function and acceptable complication profiles [14,15]. Nevertheless, variability in patient selection, deformity patterns, fixation protocols and outcome measures has limited the generalizability of these findings. Furthermore, data from South Asian populations remain scarce, despite a substantial burden of post-traumatic and post-infectious deformities in this region.

This study was designed to comprehensively evaluate the demographic profile, operative parameters, functional outcomes, radiological correction and complication rates associated with the Ilizarov method for knee deformity correction at a tertiary referral center in Bangladesh. By systematically analyzing clinical and radiographic outcomes at one-year follow-up, this research aims to contribute region-specific evidence and clarify the effectiveness of the Ilizarov technique in managing deformities around the knee joint.

II. Materials & Methods

This was a cross-sectional observational study conducted at the Department of Reconstructive and Deformity Correction Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh and a private hospital in Dhaka, Bangladesh. The study period extended from January 2018 to December 2024. A total of 25 patients with deformities around the knee joint managed using the Ilizarov technique were included in this study.

Selection criteria

Inclusion criteria

- Patients aged 10–45 years
- Deformity involving the knee joint (varus, valgus, flexion, or combined)
- Post-traumatic, post-infective, or congenital etiology

Exclusion criteria

- Refusal to Ilizarov surgery.
- Neuromuscular disorders affecting lower limb alignment
- Severe systemic illness causes the patient to be unfit for surgery.

Data Collection Procedure

Data were collected prospectively using a structured case record form. Baseline demographic variables, clinical history, etiology, side of involvement and duration of deformity were recorded at admission. Preoperative assessment included clinical examination, standardized radiographs and measurement of mechanical axis deviation, knee range of motion, limb length discrepancy and Knee Society Score. Before every operation, each patient was thoroughly informed about the surgical procedure, post-operative follow-up schedule, instructions for frame care, potential post-operative problems and complications related to surgery and fixation.

Surgical Procedure

A detailed preoperative radiological assessment was performed in all patients using a scanogram. A template was created on the scanogram to identify the actual pathology and origin of the deformity. The anatomical axes, mechanical axes, Center of Rotation of Angulation (CORA), mechanical Lateral Distal Femoral

Angle (mLDFA), mechanical Medial Proximal Tibial Angle (mMPTA), joint congruence line, anatomical Posterior Proximal Tibial Angle (aPPTA) and mechanical Medial Proximal Tibial Angle (mMPTA) were drawn and measured in degrees.

Based on this analysis, an Ilizarov frame was constructed. Intraoperatively, the frame was applied with wires placed proximal and distal to the CORA. The two segments of the frame were connected using hinges and rods. Osteotomy was performed according to standard rules. Following osteotomy, the frame was properly locked. Gradual correction of the deformity began 7 days after surgery (the latent period) at a rate of 1 mm every 12 hours (total 2 mm per day), resulting in an angular correction of 2°–6° per day, depending on the hinge distance from the CORA.

Postoperative follow-up was conducted at 7 days, 15 days and then monthly until frame removal. After the correction phase was complete, we waited for full consolidation of the regenerated bone. During this period, supervised physiotherapy was administered to prevent joint stiffness and muscle wasting. Functional outcomes were reassessed at one year using identical preoperative assessment tools to ensure consistency and reliability. Informed consent was obtained from all participants and the confidentiality of patient information was strictly maintained throughout the study.

Figure 1. Scanogram shows the deformity in the right femur distally.

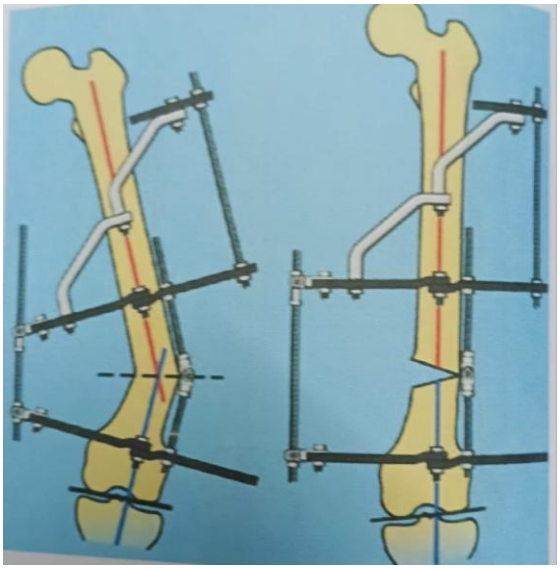

Figure 2. Determination of the Center of Rotation of Angulation (CORA) & diagrammatic frame construction on preoperative scanogram.

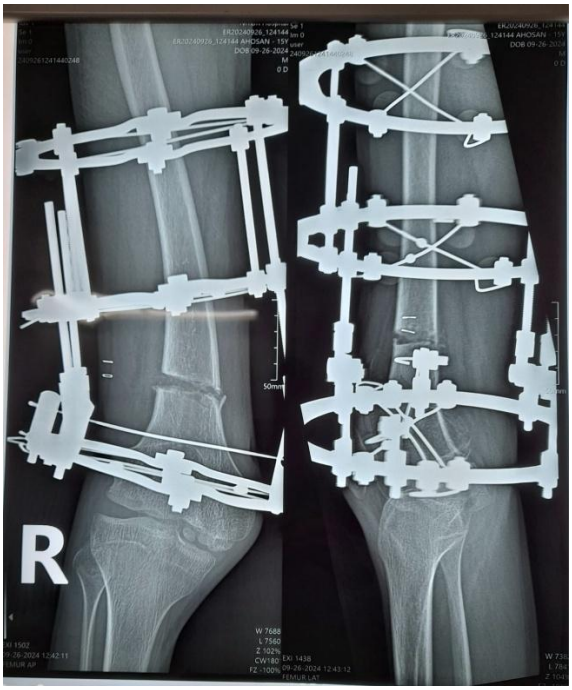

Figure 3. Level of corticotomy (osteotomy) at the level of CORA & placement of hinges & frame construction.

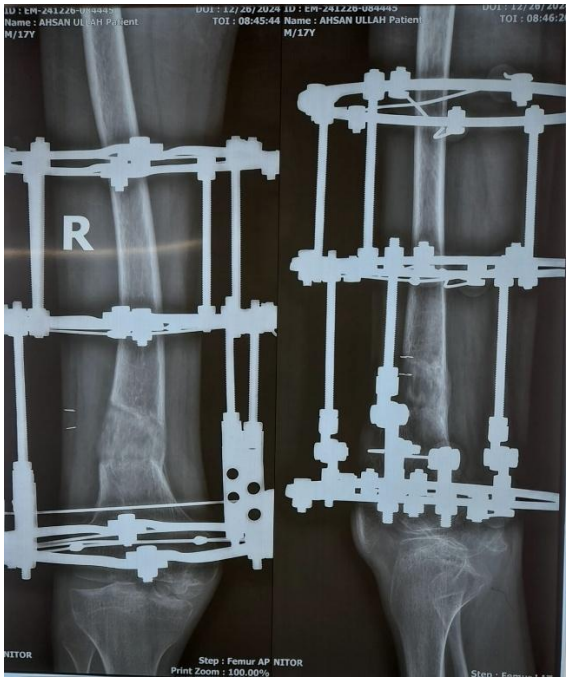

Figure 4. After correction of deformity.

Statistical Analysis

Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Pre- and postoperative outcomes were compared using paired statistical tests, with $p < 0.05$ considered statistically significant.

Figure 1. Preoperative clinical photograph for case 1

Figure 2. Preoperative full-length standing radiograph for case 1

Figure 3. Postoperative radiograph after correction of deformity.

Figure 4. Postoperative clinical photograph after full correction of the deformity (Case 1).

Figure 1: Pre-operative clinical photograph for case 2 (Bilateral genu varum deformity).

Figure 2: Pre-operative radiograph for case 2

Figure 3: Post-operative clinical photograph after correction of deformity before removal of Ilizarov fixation (Case 2).

Figure 4: Post-operative follow-up radiograph after correction of deformity (case 2).

Figure 5: After full correction of deformity (Case 2)

Figure 6: After full correction of deformity (case-2).

III. Results

Table 1: Baseline Characteristics of Study Population (n = 25)

Characteristic		Frequency (n)	Percentage (%)
Age (years), mean (SD)		28.4 ± 8.2	
		Range: [18-45]	
Gender	Male	16	64
	Female	9	36
Laterality	Right	10	40

	Left	12	48
	Bilateral	3	12
Etiology	Post-traumatic	12	48
	Post-infectious	8	32
	Congenital	5	20
Deformity Type (Frontal plane)	Varus	15	60
	-Femoral Varus	9	36
	- Tibial Varus	6	24
	Valgus	7	28
	Combined/others	3	12
Deformity Type (Sagittal plane)	Procurvatum	4	16.0
	Recurvatum	2	8.0
	Neutral	19	76.0
Duration of Deformity (years), mean ± SD		5.6 ± 3.1	

Table 1 presents the baseline demographic and clinical characteristics of the study participants. The mean age of the patients was 28.4 ± 8.2 years, with ages ranging from 18 to 45 years. Male patients constituted the majority (64%), while females accounted for 36%. Deformity involvement was more frequent on the left side (48%) compared to the right side (40%), with bilateral involvement observed in 12% of cases. Post-traumatic etiology was the most common cause of deformity (48%), followed by post-infectious (32%) and congenital causes (20%). Regarding frontal plane deformities, varus deformity was present in 60% of patients (femoral varus: 36%, tibial varus: 24%), valgus deformity in 28% and combined deformities in 12%. In the sagittal plane, procurvatum was observed in 16% of patients, recurvatum in 8%, while 76% had neutral sagittal alignment. The mean duration of deformity before intervention was 5.6 ± 3.1 years.

Table 2: Operative and Fixation Parameters

Variable		Frequency (n)	Percentage (%)
Duration of Ilizarov fixation (weeks)		18.5 ± 4.6	
Type of frame	Hinged ring fixator	14	56.0
	Standard circular fixator	11	44.0
Average latency before distraction (days)		7.2 ± 1.6	
Distraction rate (mm/day)		1.0 ± 0.2	

Table 2 describes the operative and fixation-related parameters associated with the Ilizarov technique. The mean duration of external fixation was 18.5 ± 4.6 weeks. Hinged ring fixators were used in 56% of cases, whereas standard circular fixators were applied in 44%. The mean latency period before distraction was 7.2 ± 1.6 days and the average distraction rate was maintained at 1.0 ± 0.2 mm per day.

Table 3: Functional and Radiological Outcomes at 1-Year Follow-up

Parameter	Preoperative Mean ± SD	Postoperative Mean ± SD	Mean Improvement	p-value
Mechanical Axis Deviation (mm)	28.4 ± 6.1	4.2 ± 3.7	24.2	< 0.001
Range of Motion (°)	64.8 ± 18.2	112.3 ± 16.7	47.5	< 0.001
Knee Society Score	48.6 ± 10.4	86.2 ± 9.8	37.6	< 0.001
Limb Length Discrepancy (mm)	15.3 ± 5.9	4.6 ± 3.2	10.7	0.002
Radiological Union Time (weeks)	-	21.4 ± 3.8	-	-
Residual Deformity, n (%)	-	5 (20.0%)	-	-

Table 3 summarizes the functional and radiological outcomes at one-year follow-up. Mechanical axis deviation improved from a preoperative mean of 28.4 ± 6.1 mm to 4.2 ± 3.7 mm postoperatively, showing a mean correction of 24.2 mm ($p < 0.001$). Knee range of motion increased from 64.8 ± 18.2° preoperatively to 112.3 ± 16.7° postoperatively ($p < 0.001$). The Knee Society Score improved significantly from 48.6 ± 10.4 to 86.2 ± 9.8 ($p < 0.001$). Limb length discrepancy reduced from 15.3 ± 5.9 mm to 4.6 ± 3.2 mm ($p = 0.002$). The mean radiological union time was 21.4 ± 3.8 weeks. Residual deformity, defined as mechanical axis deviation greater than 10 mm or residual angulation exceeding 5° in any plane, was observed in 5 patients (20.0%) at final follow-up.

Table 4: Complications During 1-Year Follow-Up (n=25)

Complication	Frequency (n)	Percentage (%)
Pin-tract Infection (Superficial)	5	20.0
Pin-tract Infection (Deep)	1	4.0
Frame Loosening	2	8.0
Knee Stiffness (>20° residual)	14	56.0
No Complications	5	20.0

Table 4 outlines the complications observed during the one-year follow-up period. Superficial pin-tract infection was the most frequent complication (20%), while deep pin-tract infection occurred in 4% of cases. Frame loosening was reported in 8% of patients. Residual knee stiffness exceeding 20° was observed in 56% of cases. No complications were documented in 20% of patients.

IV. Discussion

The present study evaluated the effectiveness of the Ilizarov method in correcting deformities around the knee joint and demonstrated significant improvements in mechanical alignment, functional outcomes and limb length parameters at one-year follow-up. The findings support the versatility and reliability of gradual deformity correction using circular external fixation, particularly in patients with complex etiologies such as post-traumatic and post-infectious deformities.

In this cohort, post-traumatic deformity represented the most common etiology, consistent with prior studies reporting trauma as a leading cause of knee malalignment in young adults, especially in regions with high rates of untreated fractures and limited early reconstructive care [1,16]. The relatively young mean age observed in this study aligns with reports by Xu et al. and Leonchuk et al., who emphasized that deformities around the knee often present in early adulthood following childhood or adolescent injury or infection [3,8]. The prolonged duration of deformity before intervention highlights delayed access to definitive correction, a factor frequently noted in low- and middle-income settings [10,17].

Operative parameters in this study, including latency period, distraction rate and fixation duration, were comparable to established Ilizarov protocols. The average distraction rate of approximately 1 mm/day is widely regarded as optimal for maintaining regenerate quality while minimizing complications [4,14]. The predominant use of hinged ring fixators reflects the need for controlled angular correction and preservation of joint congruity, particularly in deformities involving flexion or combined planes. Similar fixation strategies have been reported to enhance the accuracy of correction and allow functional joint movement during treatment [1,18].

Significant correction of mechanical axis deviation observed in this study underscores the precision achievable with gradual correction techniques. The magnitude of alignment improvement is comparable to outcomes reported by Warner et al. and Hussein et al., who demonstrated reliable restoration of lower limb alignment using Ilizarov-assisted osteotomies [9,19]. Restoration of near-normal mechanical axis is clinically relevant, as persistent malalignment is associated with abnormal joint loading and progression of degenerative changes [2,5].

Functional outcomes showed marked improvement, particularly in knee range of motion and Knee Society Score. The substantial gain in knee motion reflects the advantage of gradual soft-tissue stretching inherent to the Ilizarov technique, which reduces the risk of abrupt contracture and neurovascular compromise seen with acute correction [20,21]. Similar functional recovery has been reported by Ihab and Zhai et al., who emphasized the role of gradual distraction in improving joint mobility even in long-standing stiffness [10,11]. Improvement in Knee Society Score observed in this study aligns with reports indicating enhanced pain relief, stability and functional capacity following deformity correction [22].

Reduction in limb length discrepancy further highlights the capacity of the Ilizarov method to address combined deformity and shortening simultaneously. This dual correction capability distinguishes external fixation from internal fixation techniques, which often require staged procedures [13]. The mean radiological union time observed in this study was consistent with previous reports and reflects satisfactory bone healing under controlled mechanical stimulation [14,23].

Complication rates in the present series were within acceptable limits and comparable to those reported in the literature. Superficial pin-tract infection was the most common complication, a well-recognized issue associated with external fixation and generally manageable with local care and antibiotics [12]. The incidence of knee stiffness, although notable, is consistent with reports involving long-standing deformities and emphasizes the severity of preoperative soft-tissue adaptation rather than failure of correction [7,20]. Importantly, a substantial proportion of patients experienced no complications, reinforcing the overall safety of the technique when meticulous protocol adherence is maintained.

Collectively, these findings corroborate existing evidence that the Ilizarov method offers a powerful and adaptable solution for complex knee deformities. Its ability to achieve precise alignment correction, improve joint function and manage limb length discrepancy in a single construct underscores its continued relevance in

contemporary deformity reconstruction, particularly in resource-constrained settings where delayed presentation is common.

Limitations and Recommendations

The study was limited by a small sample size and single-center design. Larger, multicenter studies with longer follow-up are recommended to validate these findings and refine patient selection criteria.

V. Conclusion

The Ilizarov method proved to be an effective and versatile technique for correcting deformities around the knee joint, achieving significant improvements in alignment, joint function and limb length. Acceptable complication rates and reliable radiological union support its continued role in managing complex and long-standing knee deformities.

Acknowledgment: I would like to express my sincere gratitude for the invaluable support and cooperation provided by the staff, participants and my co-authors/colleagues who contributed to this study.

Conflicts of interest: There are no conflicts of interest.

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