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Functional Outcome of Knee Arthrodesis with an External Fixator

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Abstract: ***Background**: Knee arthrodesis was initially developed as a treatment for serious joint infections, like tuberculosis, prior to the introduction of antibiotics and modern joint replacement options. The main goal is to relieve pain and eradicate infection by achieving a stable, fused knee joint. It continues to be a vital option for patients in whom total knee arthroplasty is not suitable—particularly those with persistent infections, extensive bone loss, or failed knee replacements. Numerous studies have reported successful outcomes using external fixators for knee fusion, largely because infection remains the most common reason for performing this procedure. In our study, we focused on knee arthrodesis using external fixators, which are cost - effective and relatively simple to apply. **Methodology**: A retrospective study was carried out over a period of 18 months, involving 30 patients. The study included individuals who had knee joint infections (either septic or tuberculous), unsuccessful total knee arthroplasty, failed fracture fixation near the knee, or neuropathic knee joints. Patient assessment was performed using both the preoperative and postoperative Knee Society Score, along with the Knee Society Functional Score. **Results**: In this study, 80% of the participants were male. The most frequent indications for knee arthrodesis were septic arthritis and tuberculosis. Over 70% of the patients had undergone previous surgical procedures on the same knee. The duration for which the external fixator was applied varied from 32 to 39 weeks (approximately 7.5 to 9.1 months), with an average duration of 35.73 weeks (8.34 months). The final follow - up period ranged between 9.5 and 18 months, averaging 14.1 months. Preoperatively, the Knee Society Score ranged from 5 to 22, with an average of 16.2, while postoperative scores improved significantly, ranging from 50 to 56, with an average of 54. The functional score before surgery ranged from 40 to 50 (average 43.60), which increased postoperatively to a range of 80 to 100, with an average of 89.66. **Conclusions**: Fusion using an external fixator is a straightforward, cost - effective technique that offers a relatively comfortable experience for patients. This method is associated with fewer complications and demonstrates a high success rate in achieving joint fusion.*

Keywords: Knee arthrodesis, External fixator, Tuberculous arthritis, Post- septic sequelae, Post traumatic sequelae

1. Introduction

Knee arthrodesis has been a recognized surgical procedure since the early 20th century. The earliest known fusion was performed by Professor Albert of Vienna to address a flail knee resulting from poliomyelitis. While such indications were common in the past, the leading reason for knee arthrodesis today is a failed total knee arthroplasty. In developing regions, this procedure is frequently employed in cases of joint infection or arthritis secondary to tuberculosis or trauma. The use of external fixation in knee fusion dates back to 1948 [1], when it was first used to provide compression at the fusion site. Over time, advancements in hardware, such as larger diameter and radially preloaded half pins, have improved the biomechanical stability of external fixators. One such method involves using a monolateral external fixator, specifically the dynamic axial fixator (DAF, Orthofix SRL, Verona, Italy), which has also been applied successfully to manage bone defects [2]. In the current series, we utilized a monorail external fixator to achieve both fixation and compression in patients with sequelae from either infection or trauma (Figs.1, 2). Today, knee arthrodesis is considered a specialized treatment option, typically reserved for cases where conventional interventions are ineffective or contraindicated.

Surgical approaches have continued to evolve, with the mid - 20th century marking the introduction of internal fixation methods—such as intramedullary nails, plates, and screws—that have significantly improved joint stabilization and healing outcomes [3]. Despite these advancements, there remains no standardized choice of external fixator for knee arthrodesis. Various configurations, including unilateral, bi - planar, and circular fixators, have been described in the literature [4, 5]. The majority of published data highlight the utility of external fixation in cases where infection is the predominant indication [4, 6, 7]. However, fewer contemporary studies focus exclusively on arthrodesis achieved by compression with a unilateral external fixator. This study investigates the use of external fixators for knee arthrodesis, emphasizing the ease of application and cost - effectiveness of the technique. The primary objective is to evaluate clinical and functional outcomes—specifically pain

reduction, gait improvement, and overall mobility. By analyzing these factors and related complications, the study aims to guide orthopedic surgeons in making evidence - based decisions, thereby enhancing patient outcomes in complex knee pathologies.

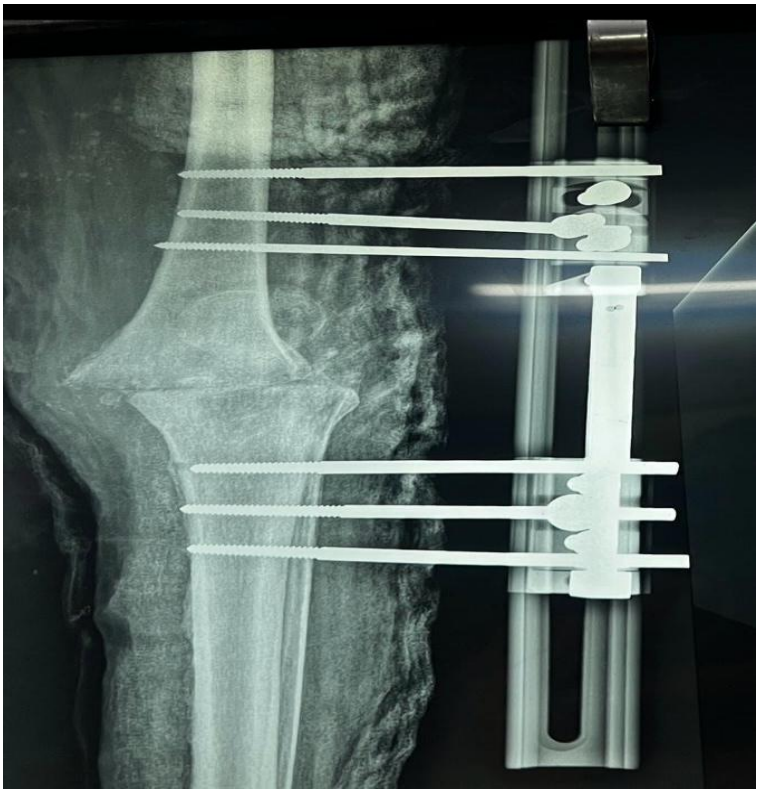

Figure 1: Immediate post - operative antero - posterior plain radiographs showing knee arthrodesis performed with an monorail fixator

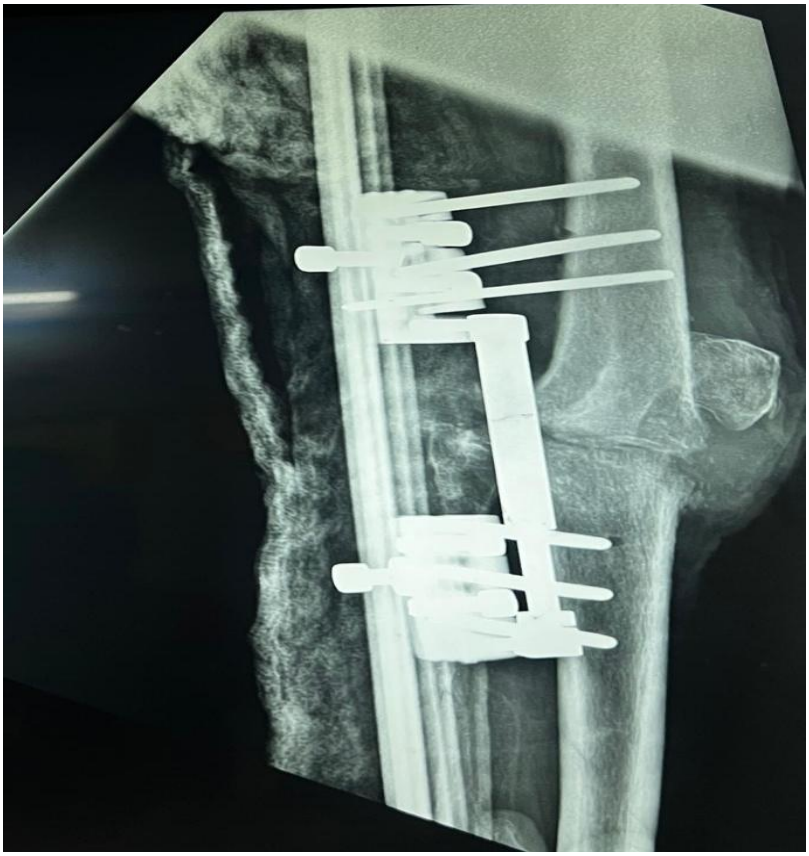

Figure 2: Immediate post - operative lateral plain radiograph showing knee arthrodesis performed with an monorail fixator

2. Methodology

This retrospective study was conducted at the Government Medical College, Kota, and included a total of 30 patients who underwent knee arthrodesis using an external fixator. The study period spanned from April 2022 to September 2023. Ethical approval was obtained, and all participants provided written informed consent prior to the surgical procedure. A comprehensive medical history and records of previous treatments were reviewed for all patients. Preoperative radiographs were obtained, and each patient was thoroughly counseled regarding the limited viability of joint - preserving procedures. They were informed about the nature of arthrodesis, including the resulting loss of knee joint mobility and potential limb shortening, which would be managed using a shoe raise. Patients were provided with long knee braces and given a day during the preoperative assessment to finalize their decision. Informed consent, detailing the procedure and expected postoperative limitations, was obtained and documented. All surgeries were performed by a single orthopedic surgeon with over 25 years of experience in the field. Once fitness for anesthesia was confirmed, patients proceeded with the arthrodesis procedure.

Inclusion and Exclusion Criteria

Patients aged 18 years and above who consented to participate and were treated with external fixation for knee arthrodesis were included. Indications for arthrodesis included septic or tuberculous infection of the knee, failed total knee arthroplasty, unsuccessful fracture fixation around the knee joint, and neuropathic joint conditions.

Patients were excluded if they met any of the following criteria: refusal to participate, follow - up duration of less than six months, arthrodesis performed for bone malignancies, bilateral knee involvement, or concurrent ipsilateral hip joint pathology.

3. Operative Technique

All surgical procedures were conducted under strict aseptic and antiseptic conditions. Patients were positioned supine on a standard operating table, with a radiolucent surface and pneumatic tourniquet applied in each case. The goal for knee alignment during arthrodesis included neutral rotation, 10–15 degrees of flexion, and 7–10 degrees of valgus. An anterior approach was used to access the knee joint, with the incision modified as needed to accommodate existing scars. The patella was mobilized laterally and either excised or its articular surface was removed, with the remaining bone utilized as a graft to support fusion. The joint space was thoroughly debrided, including removal of granulation tissue, infected or granulomatous synovium, and eburnated cartilage. Bone surfaces of the distal femur and proximal tibia were cut until healthy, bleeding cancellous bone was visible. The tibial cut was angled slightly posteriorly and laterally to facilitate appropriate alignment. For cases utilizing the Orthofix monorail external fixator, the most proximal pin was placed centrally in the distal femoral diaphysis along the sagittal plane. The tibial pin was inserted just medial to the tibial crest, also in the sagittal plane, ensuring slight valgus alignment. A minimum of three pins were inserted on either side, and all were secured using a single clamp to enable compression through the monorail. In most cases, the patella was repositioned over the fusion site during wound closure. Fixation of the patella with screws or pins was generally unnecessary unless excision was required due to poor soft tissue conditions. Wound irrigation was performed before closure, and surgical drains were placed. Care was taken to maintain an optimal distance between the skin and the external rail—close enough for biomechanical stability but far enough to allow wound care, especially with the knee in flexion. In cases with soft tissue deficits, additional procedures such as medial or lateral gastrocnemius flaps were employed. Postoperative care included early mobilization with weight - bearing as tolerated. Partial weight - bearing with support was encouraged for at least three months. Radiographic assessments were carried out at six - week intervals for up to six months (Fig 3, 4). Patients were instructed in proper pin site hygiene. Fusion was assessed radiologically based on the presence of bridging trabeculae, sclerosis, and blurring of the osteotomy margins. Radiographic union was defined by the continuity of trabecular patterns in at least two of four views (anteroposterior and lateral). At this stage, patients were allowed full weight - bearing using a walker. After approximately one month, plaster support was removed. Pin removal was performed once patients demonstrated radiographic union and functional benchmarks, including the ability to perform a straight - leg raise and independently bear weight on the operated limb for at least 30 seconds. Final mobilization included full weight - bearing with a shoe raise if limb shortening was present. Patients were scheduled for biannual follow - up appointments (Fig 5).

4. Data Collection and Statistical Analysis

Functional outcomes were assessed using both the Knee Society Score (KSS) and the Knee Society Functional Score, calculated via an online tool (https: //orthotoolkit. com/knee - society - score/). Data were compiled in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Quantitative variables were reported as means with standard deviations, while categorical variables were expressed as frequencies and percentages. A paired t - test was employed to compare preoperative and postoperative KSS values. A p - value of less than 0.05 was considered statistically significant.

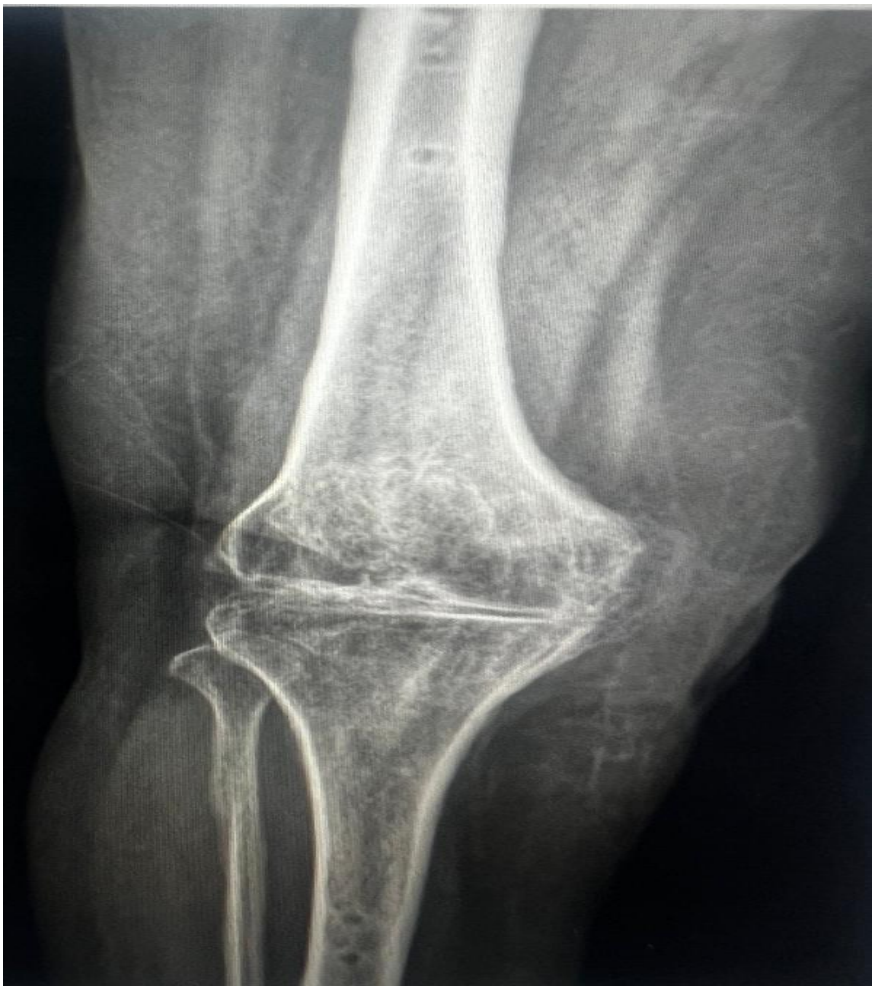

Figure 3: Antero - posterior plain radiograph at six months with consolidation at the arthrodesis site

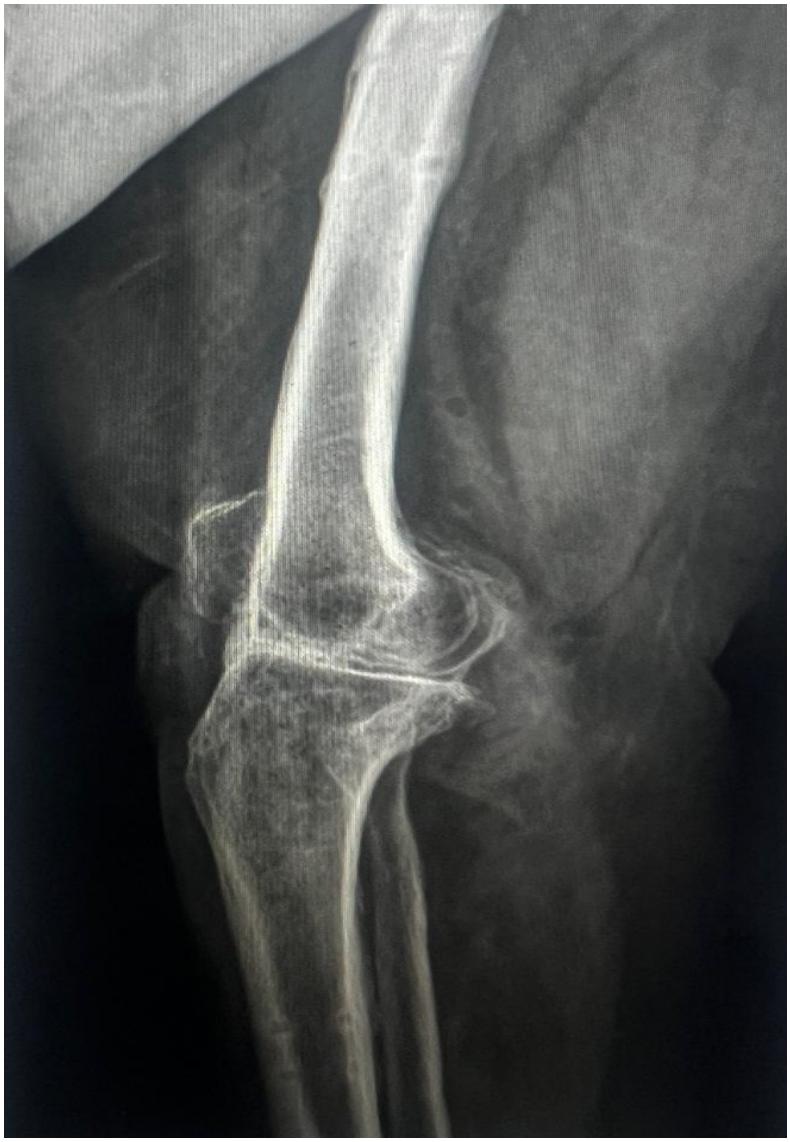

Figure 4: Lateral plain radiograph at seven months showing good consolidation at the arthrodesis site

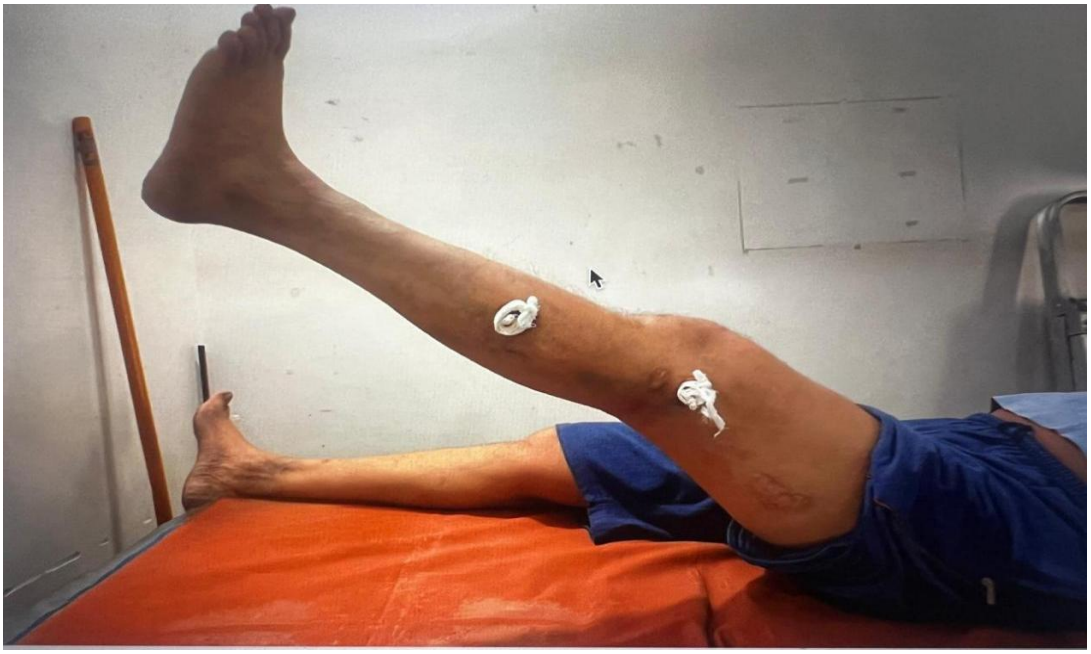

Figure 5: Patient performing the straight leg raise test after the removal of external fixator

5. Results

In this study, the majority of patients were male, accounting for 80% (24 out of 30). Most participants (80%) were within the age range of 51 to 70 years. The left knee was affected in 60% (18 patients), while the right knee was involved in 40% (12 patients). The most common indications for knee arthrodesis were septic arthritis and tuberculosis, each comprising 33.33% of the cases (10 patients each). Other indications included failed total knee arthroplasty (TKR) in 6 patients (20%), rheumatoid arthritis in 2 patients (6.66%), and neuropathic joint disease in 2 patients (6.66%). Comorbidities were also noted: diabetes mellitus was present in 4 patients (13.33%), and hypertension in 2 patients (6.66%). A summary of demographic data is presented in Table 1. A significant proportion of patients (73.33%, or 22 out of 30) had undergone previous surgical interventions on the same knee.

Of these:
- 10 patients (33.33%) had a history of one prior surgery,
- 10 patients (33.33%) had undergone two surgeries,
- 2 patients (6.67%) had undergone three surgeries.

These prior procedures included joint aspirations, debridement, implant removals, and spacer insertions (Table 2).

The average hospital stay was 12 days, ranging from 10 to 14 days. The duration of fixator application, defined from the date of surgery to the removal of pins, ranged from 32 to 39 weeks (approximately 7.47 to 9.1 months), with an average duration of 35.73 weeks (8.34 months). Notably, patients with septic arthritis had the shortest duration of fixation, while those with rheumatoid arthritis experienced the longest (Table 3).

Table 1: Patient demographics

No. of Patients (n=30)		
Sex	Male	24 (80%)
	Female	6 (20%)
Age (years)	41 - 50	2 (6.66%)
	51 - 60	10 (33.33%)
	61 - 70	14 (46.66%)
	71 - 80	4 (13.33%)
Side	Right	12 (40%)
	Left	18 (60%)
Comorbities	Diabetes Mellitus	4 (13.33%)
	Hypertension	2 (6.66%)
	Septic Knee	10 (33.33%)
	Tubercular Knee	10 (33.33%)
Indication for arthrodesis	Failed TKR	6 (20%)
	Rheumatoid Arthritis	2 (6.66%)
	Neuropathic Joint	2 (6.66%)

Table 2: Number of surgeries before arthrodesis

Surgery before arthrodesis	Number	Percentage (%)
0	8	26.67
1	10	33.33
2	10	33.33
3	2	6.67

Table 3: Time for fixator removal and indications

Indication for arthrodesis	Average time of fixator removal (weeks)
Septic arthritis	34.2
Tuberculous arthritis	35.6
Failed Total knee replacement	37.3
Rheumatoid arthritis	39
Neuropathic joint	36

At final follow - up, which ranged from 9.5 to 18 months (mean: 14.1 months), all patients were evaluated using the Knee Society Score (KSS), comprising two components: the knee score and the functional score.

Knee Score
- Preoperative scores ranged from 5 to 22, with a mean of 16.2.
- Postoperative scores ranged from 50 to 56, with a mean of 54.

Functional Score
- Preoperative scores ranged from 40 to 50, with a mean of 43.60.
- Postoperative scores ranged from 80 to 100, with a mean of 89.66.

These improvements in both the knee and functional scores indicate significant clinical and functional gains following knee arthrodesis with external fixation. Detailed score distributions are presented in Tables 4 and 5.

Table 4: Knee Society Score

	Preoperative	Postoperative
Range	5 - 22	50 - 56
Average	16.2	54

Table 5: Knee Society Score (Functional)

	Preoperative	Postoperative
Range	40 - 50	80 - 100
Average	43.60	89.66

All 30 patients achieved solid bony fusion, confirmed through clinical examination and radiological assessment. Superficial pin - track infections occurred in 4 patients (13.33%), all involving the tibial side. These infections were managed effectively with regular wound care and appropriate antibiotics. Notably, both affected patients were diabetic and had elevated postoperative blood glucose levels. In cases of septic arthritis, Methicillin - resistant Staphylococcus aureus (MRSA) was identified as the most common pathogen. Other isolated organisms included Streptococcus, Escherichia coli, and Klebsiella species. Despite minor postoperative infections, all patients achieved successful arthrodesis. The average limb shortening was 2.5 inches, which was managed with shoe raises tailored to each patient's requirement. To enhance pin stability, Dunham's pins—featuring serrated midsections for improved bone grip—were used. As a result, no cases of pin loosening were reported. At final follow - up, all patients were independently ambulant without walking aids, and none required additional surgical intervention on the treated knee. Patient - reported satisfaction was uniformly high.

Statistical Analysis

The mean preoperative Knee Society Score (KSS) was 16.20 ± 5.33, which significantly improved to a postoperative mean of 54.00 ± 2.27. A paired t - test confirmed that this improvement was statistically significant, with a p - value of 0.0001 (Table 6), indicating a strong therapeutic effect of the surgical procedure.

Table 6: Statistical analysis of the Knee Society Score

Knee Society Score	Mean	S. D	p value
Preoperatively	16.20	5.33	0.001
Postoperatively	54	2.27	

The mean preoperative Functional Knee Score among the enrolled patients was 46.60 ± 3.62, which improved significantly to a postoperative mean of 89.66 ± 7.89. A paired t - test was used to analyze the difference between preoperative and postoperative functional scores. The p - value of 0.0001 indicated that the improvement in functional outcomes was statistically significant (Table 7), reflecting a substantial enhancement in patients' mobility and independence following knee arthrodesis.

Table 7: Statistical analysis of the Functional Knee Score

Functional Knee Score	Mean	S. D	p value
Preoperatively	46.60	3.62	0.0001
Postoperatively	89.66	7.89	

6. Discussion

Knee arthrodesis remains a time - tested surgical approach, typically reserved for cases where joint preservation is no longer feasible. Historically, this procedure was primarily employed for managing joint infections using rudimentary methods such as immobilization and bone grafting. However, surgical advancements—especially the development of internal fixation techniques—have significantly enhanced the success rates of knee fusion. Figgie et al. [8] reported on the use of internal and external fixation in patients with rheumatoid arthritis, achieving fusion in 20 of 23 patients (27 knees). Their findings highlighted that unsuccessful outcomes were associated with ongoing infection and inadequate bone quality. In another notable study, Brown et al. [3] supported the use of antegrade intramedullary nailing for cases involving chronically infected total knee replacements (TKRs). They achieved a high fusion success rate (94%) in 16 out of 17 patients. Nevertheless, postoperative mobility was limited—only 59% of patients could walk with assistive devices, while 41% relied on wheelchairs. The complication rate was substantial at 47%, and a third of the cohort died within two years of the procedure. Eralp et al. [4] explored the use of a unilateral external fixator for arthrodesis, primarily in patients with joint infections. Their study demonstrated favorable outcomes using monolateral fixators compared to circular constructs in a group of 11 patients. The average limb shortening was 1.4 cm, except in two cases. Pin - track infections occurred in five patients but were managed with antibiotics and wound care. Fixator duration ranged from 5 to 12 months, averaging 8 months. The authors concluded that unilateral fixators offered better comfort, fewer complications, and reliable union rates. Hak et al. [5] compared outcomes between single - plane and bi - plane external fixators. Their study of 36 patients (17 in the single - plane group and 19 in the bi - plane group) revealed that increasing the number of previous surgeries reduced the likelihood of successful fusion. Both groups had comparable fusion rates—58% for single - plane and 65% for bi - plane fixators. They emphasized the challenges of achieving arthrodesis in the presence of significant bone loss. Brodersen et al. [6] assessed 45 cases of failed TKR treated with external fixation. Their findings suggested that the choice of fixation technique did not significantly alter final outcomes. Fixators were retained for approximately 10 weeks, followed by cast immobilization to ensure successful fusion. MacDonald et al. [7] documented multiple techniques for achieving arthrodesis, while Benhenneda et al. [9] conducted a retrospective review of 30 cases involving infected TKRs. Using a compression clamp with a single - plane external fixator, they reported an 83% fusion rate over a mean follow - up of 42.5 ± 23.6 months. Pin - track infections emerged as the most common complication. Bae et al. [10] reported on nine cases—six involving tuberculosis and three with infected TKRs—treated with external fixation. Fusion was achieved in all patients over an average fixator duration of 4.4 months, with a mean follow - up of 16.5 months. Other studies have explored various methods of achieving knee arthrodesis. These include techniques such as dual plating [11], monorail external fixators [12], crossed cannulated screw fixation [13], and circular external fixators [14]. Lohith et al. [15] noted successful fusion in valgus (5°–7°) and flexion (5°–15°) alignment. They supported compression arthrodesis as a viable option but also pointed to emerging methods like dual plating, short locked intramedullary nails, and arthroscopy - assisted fusion as potentially more effective. Eralp et al. [16] further emphasized the value of intraoperative imaging for accurate Schanz screw placement and bone cuts, which is essential to minimize malalignment.

7. Conclusions

Knee arthrodesis using an external fixator is a simple, cost - effective, and patient - friendly procedure, particularly in cases of post - infective or post - traumatic knee conditions. The technique involving a single anterior monorail fixator provides reliable joint stabilization and facilitates early weight - bearing and functional recovery. This single - stage approach offers a practical alternative to more complex and resource - intensive staged reconstructions or revision arthroplasty, especially in settings where such interventions are not feasible. External fixation is especially suitable for patients with septic or tuberculous arthritis, failed total knee arthroplasty (TKA), advanced rheumatoid arthritis, failed internal fixation around the knee, or neuropathic joints—conditions in which joint preservation techniques are unlikely to succeed. Thorough preoperative counseling about the expected limb shortening and duration of external fixation plays a key role in patient compliance and satisfaction. Among the various arthrodesis techniques—internal fixation, external fixation (uniplanar, biplanar, or circular), or hybrid constructs—external fixation stands out due to its ease of application, lower complication rates, and high fusion success. In our study, significant improvements were observed in both the Knee Society Score and Functional Knee Score postoperatively, indicating strong

clinical and functional outcomes. In summary, external fixation remains a valuable and effective treatment option for knee arthrodesis in select patients, delivering solid fusion with fewer complications and excellent functional restoration.

Additional Information

Author Contributions
All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Aakash Bansal, R P Meena

Acquisition, analysis, or interpretation of data: Aakash Bansal, Rohit Kharalwa, Shreyas B L

Drafting of the manuscript: Aakash Bansal, Rohit Kharalwa

Critical review of the manuscript for important intellectual content: Aakash Bansal, Umesh Kumar Meena, R P Meena, Rohit Kharalwa, Shreyas B L

Supervision: Umesh kumar Meena

Conflict of interest
No conflict of interest

Informed consent
Informed consent was obtained from all individual participants included in the study.

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