



OUTCOMES ANALYSIS OF ANKLE ARTHRODESIS VIA TRANSFIBULAR APPROACH WITH ILIZAROV RING

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ABSTRACT **Introduction:** Ankle arthrodesis remains the gold-standard treatment for end-stage ankle arthritis, particularly in younger and active patients. The trans fibular approach combined with Ilizarov ring fixation offers potential advantages, including early weight-bearing, deformity correction, can be used in infective cases and improved fusion rates. This study evaluates the functional and radiographic outcomes of this technique. **Methodology:** A prospective observational study was conducted on 22 patients undergoing ankle arthrodesis using the transfibular approach and Ilizarov ring fixation. Patients were assessed based on American Orthopaedic Foot and Ankle Society (AOFAS) scores, Visual Analogue Scale (VAS) scores, and radiographic union rates. Statistical analysis included paired t-tests and chisquare tests to determine improvements in functional and pain outcomes. **Results:** The mean age of patients was 47.35 ± 9.45 years, with a male predominance (63.64%). Most injuries (63.64%) were caused by road traffic accidents. The AOFAS score significantly improved from 39.22 ± 5.12 preoperatively to 88.56 ± 3.78 postoperatively ($p < 0.0001$). The VAS score reduced from 8.35 ± 1.23 to 1.02 ± 0.22 ($p < 0.0001$). Radiographic union was achieved in all cases by nine months. Complications were minimal, with 18.18% of patients experiencing pin-track infections and 4.55% having delayed union. Patients without comorbidities demonstrated better functional outcomes. **Conclusion:** Overall, the technique proved highly effective in improving mobility and reducing pain, with steady recovery and high fusion success. Future research should focus on larger trials, comparisons with other fixation methods, and optimizing rehabilitation protocols.

KEYWORDS : Ankle arthrodesis, Ilizarov ring fixation, transfibular approach, end-stage ankle arthritis, functional outcomes, radiographic union.

INTRODUCTION

Ankle arthrosis is a common condition managed with both conservative and surgical strategies. Nonoperative measures include activity modification, NSAIDs, supplements such as glucosamine and grape seed extract, mobility aids, and physical therapy including the Feldenkrais method. Orthotic modifications such as rocker-bottom shoes, SACH, AFOs, or custom ankle braces may also be beneficial. [1] Surgical interventions are considered when conservative therapy fails, including arthroscopic debridement, synovectomy, joint distraction, osteophyte removal, and arthrodesis, though arthroscopy in advanced stages often yields limited results. [1] Ankle arthrodesis remains a reliable option for end stage ankle arthritis (ESAA), aiming for a stable, pain-free, plantigrade foot in slight valgus, neutral dorsiflexion, and mild external rotation. [2] Although total ankle replacement offers functional benefits, it carries higher risks of complications. [3] Large databases confirm arthrodesis as the most commonly performed procedure for ESAA. [4] Fusion can be achieved by open or arthroscopic techniques, with outcomes influenced by approach, patient factors, and anatomical considerations. [5] Proper alignment involves neutral dorsiflexion, mild external rotation, and valgus of 0° – 5° . [1] The open method allows bone graft placement and deformity correction but requires extensive exposure, increasing wound risks. Albert first described ankle arthrodesis in the late 19th century. [6] Over time, anterior, posterior, lateral, and transmalleolar approaches have evolved. In high-risk or resource-limited cases, external fixators such as the Ilizarov device gained popularity for their minimally invasive nature and ability to manage infection, deformity, and limb shortening. [7] The transfibular approach provides excellent joint exposure, deformity correction, a wide contact area, and permits fibular autograft use, thereby improving fusion rates. [8] Lateral soft tissue coverage also reduces complication rates. [9] Intramedullary nailing provides strong biomechanical stability but is generally reserved for salvage or severe deformities after failed arthroplasty. [10] Internal fixation techniques, however, carry risks of infection and hardware-related issues. [11] With rising incidence of arthritis due to diabetes, rheumatoid arthritis, and failed arthroplasty, surgical strategies must adapt to achieve optimal results. [12] This study evaluates the clinical and functional outcomes of ankle arthrodesis using the transfibular approach with Ilizarov ring fixation in ESAA patients. Outcomes analyzed include

union rate, time to union, complication rate, pain relief, functional improvement, and satisfaction. Special emphasis is placed on deformity correction, maintenance of limb length, and facilitation of early weight-bearing.

MATERIAL AND METHODS

This study was conducted in the Department of Orthopaedics, M.L.N. Medical College, Prayagraj. The study design was a prospective observational study, carried out over a period of one year (2024-2025). The study population included patients who underwent ankle arthrodesis with a circular external fixator using the Ilizarov method. A non-probability convenience sampling technique was used, and a total of 22 patients were included. The inclusion criteria comprised patients undergoing ankle arthrodesis with the Ilizarov method, those with a history of failed surgical treatment for fractures managed by osteosynthesis or requiring revision ankle arthrodesis, and patients with osteoarthritis including infective osteoarthritis. Exclusion criteria included patients with less than nine months of follow-up, incomplete clinical or radiographic data, and patients with severe co-morbidities affecting recovery. Ethical clearance and informed consent were obtained prior to recruitment. Clinico-demographic details of the patients were collected using a structured questionnaire. Functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score, adjusted to a maximum of 92 as ankle fusion eliminates joint motion. Scores were graded as excellent (80–92), good (70–79), fair (60–69), and poor (<60). Pain was assessed using the Visual Analogue Scale (VAS) at final follow-up following fixator removal. All patients underwent surgery using a transfibular approach. A lateral incision was made over the fibula, and the lateral malleolus was resected. The syndesmosis was debrided, and articular cartilage was removed with osteotomes and curettes. When necessary, a medial incision was made for distal tibial exposure and medial malleolus osteotomy. The reduction was performed by opposing tibio-talar surfaces to maximize bone contact and achieve plantigrade foot positioning, which was temporarily secured with two 3.0 mm Kirschner wires. Positioning was confirmed intraoperatively using anteroposterior and lateral radiographs. The Ilizarov fixator was then assembled. Two rings were applied to the distal tibia, fixed with two Ilizarov wires each, placed orthogonally. The hindfoot construct consisted of an anterior and posterior semi-ring connected to the

calcaneus with two posterior Schanz pins and one transverse smooth wire. The talus was stabilized with two anteromedial and anterolateral Schanz pins. All pins and wires were inserted after low-speed drilling, followed by manual placement and dressing. Incisions were closed in layers. Postoperatively, patients were allowed gradual weight-bearing as tolerated. Dressings were changed regularly, and sutures were removed at two weeks. Radiographs were taken at each follow-up to assess union. Additional compression of 1 mm was applied monthly at the arthrodesis site. After radiographic confirmation of union, stability was assessed using valgus, varus, antecurvatum, and recurvatum stress tests under weight-bearing. If no motion or pain was observed, the apparatus was retained for one additional week before removal.

Statistical Analysis:

SPSS software version 27.0 was employed to analyse the data that was recorded in an Excel sheet. Clinical history, demographic characteristics, and surgical details were summarised using descriptive statistics. Continuous variables, including age, BMI, AOFAS score, and VAS score, were represented as mean $\pm$ standard deviation (SD). Various categorical variables, such as gender distribution, injury mechanism, and complications, were presented as frequencies and percentages. The paired t-test was employed to evaluate functional improvement and pain reduction by comparing the preoperative and post-operative AOFAS and VAS scores. Radiographic union rates were examined over time using the chi-square test. Independent t-tests were implemented to assess the impact of comorbidities on functional outcomes. A p-value of less than 0.05 was taken to indicate statistical significance.



Figure-1a

Figure-1b

Figure- 1. A patient with history of Ankle arthritis. Figure 1a. Preoperative X-ray of ankle joint (AP View). Figure 1b. Preoperative X-ray of ankle joint (lateral view).

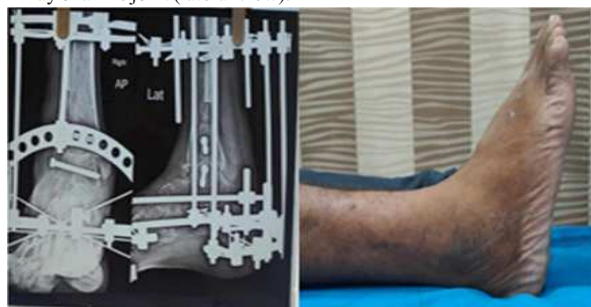


Figure 2a

Figure: 2b

Figure-2 A patient with history of Ankle arthritis. Figure 2a. Immediate postoperative X-rays. Figure 2b. Clinical pictures after frame removal.



Figure 3a

Figure: 3b



Figure 3c

Figure: 3d

Figure-3 A Patient with history of elsewhere treated case of bimalleolar fracture right side. Figure 3a. immediate postoperative X-ray. Figure 3b&3c. Post op clinical pictures with ilizarov external fixator. Figure 3d. Post op x-ray at 3 months follow-up.



Figure: 4a

Figure: 4b

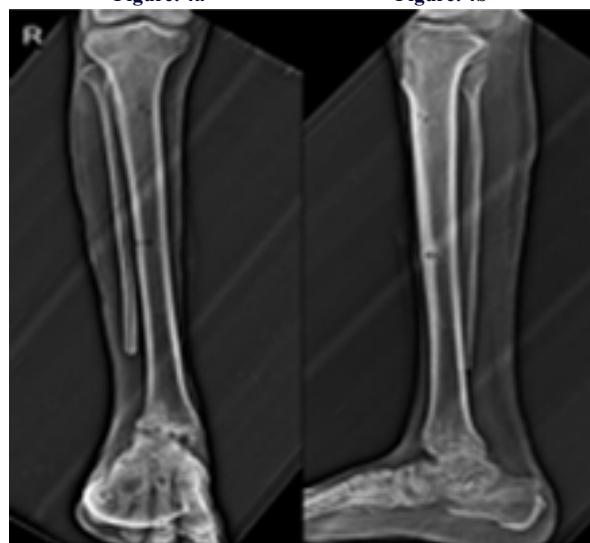


Figure-4c

Figure: 4 Few post-op x-rays showing radiological union after 9 months of follow-up.

RESULTS

The mean age of the patients was 47.35 ± 9.45 years, with most in the 40–49 years group (36.36%). Males predominated (63.64%) compared to females (36.36%). Occupation-wise, most of them (36.36%) were manual labourers. [Table-1] Injuries occurred more often on the right side (63.63%). Road traffic accidents accounted for 63.64%, while falls/slips caused 36.36%. Non-infective etiologies were present in 81.82% and infective conditions in 18.18%. [Figure-1] Mean BMI was 25.78 ± 3.21 kg/m², placing patients in the overweight range. A total of 77.27% had a prior surgery. Comorbidities included diabetes and hypertension. Mean symptom duration was 11.42 ± 6.15 months. [Table-2] All 22 patients underwent ankle arthrodesis via the trans fibular approach. Lateral malleolus osteotomy and chondral cartilage denudation were performed in 100% of cases, medial malleolus osteotomy in 31.82%. Reduction was successful in all cases. [Table-3] The AOFAS score improved from 39.22 ± 5.12 pre-operatively to 88.56 ± 3.78 at 9 months ($p < 0.0001$). VAS score

decreased from 8.35 ± 1.23 to 1.02 ± 0.22 ($p < 0.0001$). Radiographic union was seen in 4.55% at 1 month and 100% at 9 months ($p = 0.0002$). Mean time to radiographic union was 5.89 ± 1.16 months. Post-operative complications were 13.64% at 1 month, and 0% at 9 months. [Table-4] At final follow-up, normal AP alignment was observed in 90.91% and lateral alignment in 95.45%. Bridging bone across three cortices was achieved in 100%. Deformity (varus/valgus) occurred in 9.09%. [Figure-2] Overall, 77.27% had no complications; pin-tract infection was most common (18.18%). [Figure-3] Patients with comorbidities had lower AOFAS scores (86.78 ± 4.25) than those without (89.96 ± 3.16 , $p = 0.0010$). [Table-5]

DISCUSSION

This study included 22 patients (mean age 47.35 ± 9.45 years, 40–49 years: 36.36%, males: 63.64%, BMI 25.78 ± 3.21). Chalak A et al. [13] reported 20 patients (mean 44.75 years, males 75%). Kim J et al. [14] studied 24 patients with higher ages (56.9, 64.1 years), male predominance (66.67%, 58.33%), and comparable BMI (23.1 ± 3.0 , 25.2 ± 4.5). Li J et al. [15] included 72 elderly patients (65.4 years, 52.78% males, BMI 24.9 ± 3.9). Ma N et al. [16] had 88 patients (57.21 years, 53.41% males, BMI 27.92 ± 2.96). Pereira V et al. [17] studied 11 patients (44.81 years, 81.82% males). Nogod S et al. [18] reported 88 patients (52.6 years, 51.14% males). Wani S et al. [19] studied 30 patients (36–50 years: 46.66%, males 76.66%). In this study, manual laborers were most affected (36.36%), followed by office workers (31.82%), retired (18.18%), and unemployed (13.64%). Injuries mainly involved the right side (63.63%), with RTA as the leading cause (63.64%). Chalak A et al. [13] also reported right-sided predominance ($n=14$), as did Kim J et al. [14] in both groups ($n=7$, $n=9$), Li J et al. [15] (39:33), and Nogod S et al. [18] (56.8%). Pereira V et al. [14] found near-equal distribution (6 vs. 5), while Wani S et al. [19] noted more left-sided injuries (56.66%). None of the studies discussed occupation or cause. In this study, 77.27% had prior surgery, with diabetes (22.73%) and hypertension (18.18%) as common comorbidities. Mean symptom duration was 11.42 ± 6.15 months. All patients underwent transfibular ankle arthrodesis with 100% lateral and 31.82% medial malleolus osteotomy; chondral cartilage denudation and reduction were achieved in all, with only one intraoperative fracture (4.55%). Chalak A et al. [13] also reported frequent prior surgeries (avg. 1.3, range 0–4). Li J et al. [15] observed more comorbidities (smoking 56.9%, diabetes 31.9%, osteomyelitis 26.4%, rheumatoid arthritis 15.3%) and longer symptom duration (11.5 years). Nogod S et al. [18] found diabetes, rheumatoid arthritis, and poliomyelitis common, with three smokers. Pereira V et al. [17] used a similar lateral approach with malleolus osteotomy and cartilage denudation.

In this study, AOFAS scores improved from 39.22 ± 5.12 to 88.56 ± 3.78 at 9 months ($p < 0.0001$), while VAS scores declined from 8.35 ± 1.23 to 1.02 ± 0.22 ($p < 0.0001$). Radiographic union reached 100% by 9 months, with no complications at final follow-up. Kim J et al. [14] reported AOFAS improvements from 43.3 ± 4.3 to 64.4 ± 6.1 ($p = 0.003$) in Group A and 44.3 ± 4.3 to 65.3 ± 5.5 ($p = 0.002$) in Group B, with no intergroup difference ($p = 0.525$). Eylon et al. [20] noted an AOFAS of 65 with full union, while Li J et al. [15] recorded VAS reduction from 8.56 ± 1.85 to 2.72 ± 0.83 and AOFAS rise from 45.36 ± 6.43 to 80.25 ± 9.16 . Ma N et al. [16] observed similar outcomes (AOFAS 39.00 ± 8.34 to 80.65 ± 8.86 ; VAS 6.25 ± 0.91 to 0.80 ± 0.77). Pereira V et al. [17] reported lower scores (AOFAS 55.72), whereas Nogod S et al. [18] found an increase from 35.89 to 85.71 ($p < 0.001$). Long-term follow-ups in previous studies showed AOFAS scores of 62, 67, and 68.3 at 4.4–9.6 years, lower than the present 9-month outcome. Radiographic assessment showed excellent outcomes, with normal alignment in anteroposterior (90.91%) and lateral (95.45%) views, complete bridging across three cortices (100%), and mean union time of 5.89 ± 1.16 months. Pain-free status was reported by 81.82%, mild pain by 13.64%, and moderate pain by 4.55%. Chalak A et al. [13] reported complete union at 39.4 months, with most patients pain-free or mildly symptomatic, though ASAMI scores were limited by fusion-related restrictions. Li J et al. [15] observed fusion in all cases with healing in 12.7 weeks (11–18 weeks), while Yanuka M et al. [121] achieved painless fusion in 7–15 weeks. Ma N et al. [16] reported 100% fusion in 88 patients with faster healing (3.56 ± 1.04 months). Pereira V et al. [17] documented 90.9% union with minor varus deformities and subtalar degeneration in 5 cases, while Wani S et al. [19] observed subtalar arthritis in 23.33% and combined calcaneocuboid and subtalar arthritis in 6.66%, with no ankle arthritis, similar to the present study. In the present study, most patients (77.27%) remained free of complications. Pin-tract infections were the most common (18.18%), and delayed union occurred in 4.55% of

cases. Similarly, Chalak A et al. [13] reported six complications, including four pin-tract infections and one wire breakage. Li J et al. [15] observed minor pin-tract infections in 12.5%, anterior talar dislocation in 9.7%, and midfoot pain in 6.94%, all managed conservatively. Ma N et al. [16] reported minor needle-channel infections, delayed healing, or swelling in six patients, while Pereira V et al. [17] noted superficial infections and wound dehiscence, managed with dressings and antibiotics. Nogod S et al. [18] had a lower overall complication rate (11.4%), including infection (2.3%), non-union (3.4%), wound dehiscence (3.4%), neuromas (1.1%), and metalwork failure (1.1%), highlighting differences in techniques and fixation methods. In the present study, patients without comorbidities had significantly better functional outcomes (AOFAS 89.96 ± 3.16) than those with comorbidities (86.78 ± 4.25 , $p = 0.0010$), highlighting the negative impact of systemic conditions on recovery. Prior studies identified joint infection, talar necrosis, smoking, multiple comorbidities, and inadequate compression as risk factors for non-union. [22,23] Severe systemic ailments, including diabetes, vascular disease, malignancy, chronic hypoxia, malnutrition, and immune deficiencies, further hinder ankle fusion success. [24–26] Ilizarov external fixation has proven effective in such high-risk cases, as shown by Kugan R et al. [27], who reported an 83% fusion rate and improved clinical outcomes in 48 patients. Similarly, Nogod S et al. [18] and Gaedke I et al. [28] confirmed that smoking and poor glycemic control increase non-union and wound complications, reinforcing the importance of careful patient selection and perioperative optimization. The study demonstrated that ankle arthrodesis via the transfibular approach with Ilizarov ring fixation is effective for end-stage ankle arthritis. Patients showed significant functional improvement, pain relief, and 100% radiographic union by nine months, with minimal complications, mainly pin-tract infections. Outcomes were particularly favorable in patients without comorbidities, underscoring the procedure's reliability in restoring function and reducing pain.

CONCLUSION

Ankle arthrodesis using the transfibular approach with Ilizarov ring fixation proved to be an effective technique, resulting in significant functional improvement, pain relief, and high fusion success. Consequently, patients experienced steady recovery with improved mobility and minimal complications, making this method a reliable option for managing end-stage ankle arthritis. Moreover, the technique demonstrated excellent correction of deformities, preservation of limb length, and early weight-bearing, which are particularly advantageous in complex or high-risk cases. Overall, it offers a versatile and dependable solution, providing both functional and radiographic benefits, even in patients with challenging clinical profiles. However, the present study had several limitations. Specifically, the small sample size of 22 patients, short follow-up of 9 months, lack of a control group, and single-center design may limit the generalizability and long-term assessment of outcomes. Additionally, patient variability and the specialized nature of the Ilizarov technique could affect its broader applicability. Therefore, future studies should involve larger, multicenter cohorts with extended follow-up, include comparative groups using alternative surgical methods, evaluate cost-effectiveness, and explore adjuncts such as biologics and tailored rehabilitation protocols to optimize fusion rates, functional recovery, and overall patient outcomes.

Conflict Of Interest:

The authors declare that there are no conflicts of interest related to this study.

Funding:

This research did not receive any financial support from external sources.

Consent:

In accordance with international and institutional guidelines, written informed consent was obtained from all participants and securely maintained by the authors.

ETHICAL APPROVAL:

Ethical approval was obtained in line with international and institutional standards, and the documentation has been preserved by the authors.

Table-1: Demographic Parameters Of Enrolled Patients.

Socio-Demographic Characteristics	Number [n=22]	
Age	30–39	4 (18.18%)
	40–49	8 (36.36%)

	50–59	6 (27.27%)
	60–69	4 (18.18%)
Gender	Male	14 (63.64%)
	Female	8 (36.36%)
Occupation	Manual Labourer	8 (36.36%)
	Office Worker	7 (31.82%)
	Retired	4 (18.18%)
	Unemployed	3 (13.64%)

Table-2: Distribution Of Clinical History Of The Enrolled Patients.

Clinical History	Number [n=22]	
Previous Surgery History	Yes	17 (77.27%)
	No	5 (22.73%)
Comorbidities	Hypertension	4 (18.18%)
	Diabetes	5 (22.73%)
	None	13 (59.09%)
Duration of Symptoms (months)	11.42 ± 6.15	

Table-3: Distribution Of Surgical Procedure Details Of The Enrolled Patients.

Surgical Procedure	Number [n=22]	
Trans fibular Approach	22 (100%)	
Ostectomy Performed	Lateral Malleolus	22 (100%)
	Medial Malleolus	7 (31.82%)
Chondral Cartilage Denudation	Yes	22 (100%)
	No	0 (0%)
Reduction Achieved	Yes	22 (100%)
	No	0 (0%)
Complications During Surgery	No	21 (95.45%)
	Yes (Minor Intraoperative Fracture)	1 (4.55%)

Table-4: Distribution Of Surgical Procedure Details Of The Enrolled Patients.

Follow-Up Period (Months)	AOFAS Score (Mean ± SD)	VAS Score (Mean ± SD)	Radiographic Union n (%)	Complications n (%)
Preoperative	39.22 ± 5.12	8.35 ± 1.23	N/A	N/A
1 st Month	51.34 ± 6.24	7.12 ± 1.04	1 (4.55%)	3 (13.64%)
3 rd Month	63.11 ± 5.89	5.24 ± 0.98	6 (27.27%)	2 (9.09%)
6 th Month	74.78 ± 4.92	2.68 ± 0.76	15 (68.18%)	1 (4.55%)
9 th Month (Final FU)	88.56 ± 3.78	1.02 ± 0.22	22 (100%)	0 (0.00%)
Final Outcome	88.56 ± 3.78	1.02 ± 0.22	Union at 5.89 ± 1.16 months	Pain: None 81.8%, Mild 13.6%, Mod 4.6%, Sev 0%

Statistical significance: AOFAS improved from 39.22 ± 5.12 to 88.56 ± 3.78 ($t=44.54$, $p<0.0001$). VAS reduced from 8.35 ± 1.23 to 1.02 ± 0.22 ($t=33.70$, $p<0.0001$).

Table-5: Analysis The Comparison Of Final AOFAS Scores Based On Comorbidities

Group	AOFAS Score (Mean ± SD)	p-value
With Comorbidities (n = 9)	86.78 ± 4.25	$t=3.449$
Without Comorbidities (n = 13)	89.96 ± 3.16	$p=0.0010^*$



Figure-5: Clinical Details Of The Enrolled Patients.

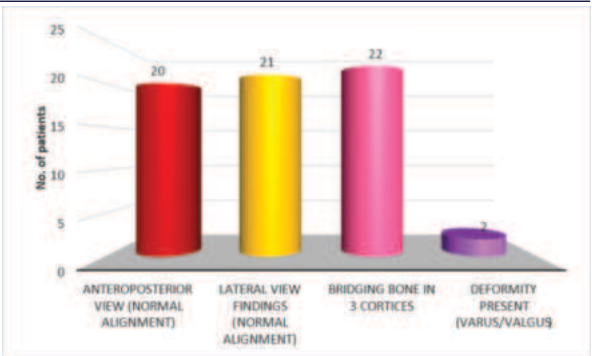


Figure-6: Radiographic Evaluation At Final Follow-up Of The Enrolled Patients.

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