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Outcome of tibial shaft fractures treated with the SIGN FIN nail at Addis Ababa Emergency, Burn, and Trauma Hospital (AaEBT) Addis Ababa, Ethiopia

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Abstract
Objectives: To determine the outcome of tibial fractures treated with the SIGN FIN nail.

Study Design: Retrospective case series study.

Study Setting: Trauma center.

Methods and Materials: We included 14 patients aged 18–51 years with 16 tibial fractures in this study. Patients were followed clinically and radiographically, and the minimum time followed was 6 months. Johner and Wruhs criteria with modification were used to assess the outcome.

Result: There were 11 male (78.6%) and three female (21.4%) patients. The mean age was 32.44 ± 8.98 (range 18–51) years. The right-sided tibia was injured in six as compared with the left side in four, and four patients had bilateral injuries. Eight (50%) fractures were closed fractures, whereas the rest eight (50%) were open types of fractures. Among the latter, half (n = 4; 50%) fractures were Gustilo type II fractures, while three (37.5%) fractures were Gustilo type III fractures, and one (12.5%) patient had a Gustilo type I fracture. All patients had radiologic union. There were no infections or secondary surgery for any reason. Excellent, good, and fair results were achieved in 62.5%, 25%, and 12.5%, respectively. All patients were able to return to their preinjury activity except two patients.

Conclusion: SIGN FIN nail is an option for treating tibial shaft fractures with good outcomes and few complications in selected fractures.

Level of evidence: Level IV

Keywords: FIN nail, intramedullary interlocking nail, SIGN nail, tibia

1. Introduction

1.1. Background

Traumatic injuries cause significant morbidity and mortality in low-income and middle-income countries (LMICs).[1–4] Road traffic accidents are responsible for most of these injuries, leading to over 1.2 million deaths and up to 50 million nonfatal injuries annually.[5]

Tibial shaft fractures represent the most prevalent long bone fractures and follow age-related and sex-related bimodal distribution, with fractures commonly occurring in young male patients and older women.[6–8] Road traffic accidents account for over half of all tibial shaft fractures; the rest occur as the result of simple falls, sports-related injuries, or direct trauma.[6,8]

Tibial fractures are treated with casts, external fixators, plating, and intramedullary nails (IMNs). Intramedullary nailing gives more rapid union with less malunion and shortening. Nailed patients have less time off work with a more predictable and rapid return to full function.[9]

The treatment of tibial fractures remains challenging in developing countries because of the lack of image intensifiers and fracture tables at many trauma centers. The Surgical Implant Generation Network (SIGN) Standard IMN is one solution for these settings. SIGN was created as a humanitarian, nonprofit corporation in Washington, USA, to provide improved health care and proper orthopaedic treatment of fractures at little or no cost to people in need throughout the world. The SIGN tibial system is a solid IMN with interlocking capability through a mechanical aiming device that enables the placement of proximal and distal interlocking screws with no need for image guidance. Over 385 hospitals currently use this system in 55 different countries.[1,10]

While the SIGN Standard Nail is highly efficacious at treating tibial fractures, locating the interlocking screw slots is challenging, time-consuming, and carries the risk of complications because of missed screws.[11,12]

SIGN developed the FIN nail, which avoids needing to place distal interlocking screws altogether. This nail possesses longitudinal "flutes" that create an interference fit with the medullary canal.

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The hospital receives free of cost implants from SIGN Fracture Care International.

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The FIN nail theoretically offers comparable rotational stability while decreasing operative time as compared with interlocking screws (Fig. 1).

FIN SIGN nail was designed initially for femoral and humeral fractures. It can be inserted antegrade or retrograde. It is best indicated for simple, diaphyseal fractures which are length stable.

A potential drawback is decreased longitudinal stability for comminuted, length unstable fracture patterns.[10]

Although there is a growing body of evidence supporting the use of the SIGN FIN nail for femoral fractures, there is no evidence of the use of SIGN FIN nail for treatment of tibial fractures.[13–15]

In this study, we report outcomes with SIGN FIN nailing of tibial fractures to compare with those performed with the standard SIGN tibial nail or other locked intramedullary nails and to determine whether there are increased complications in the SIGN FIN group. We used the SIGN FIN nail because of a shortage of standard locked nails in our setup.

2. Methods

2.1. Objectives

2.1.1. General Objective. To assess the outcome of tibial fracture treated with FIN SIGN nail at AaBET hospital from September 2015 to September 2020.

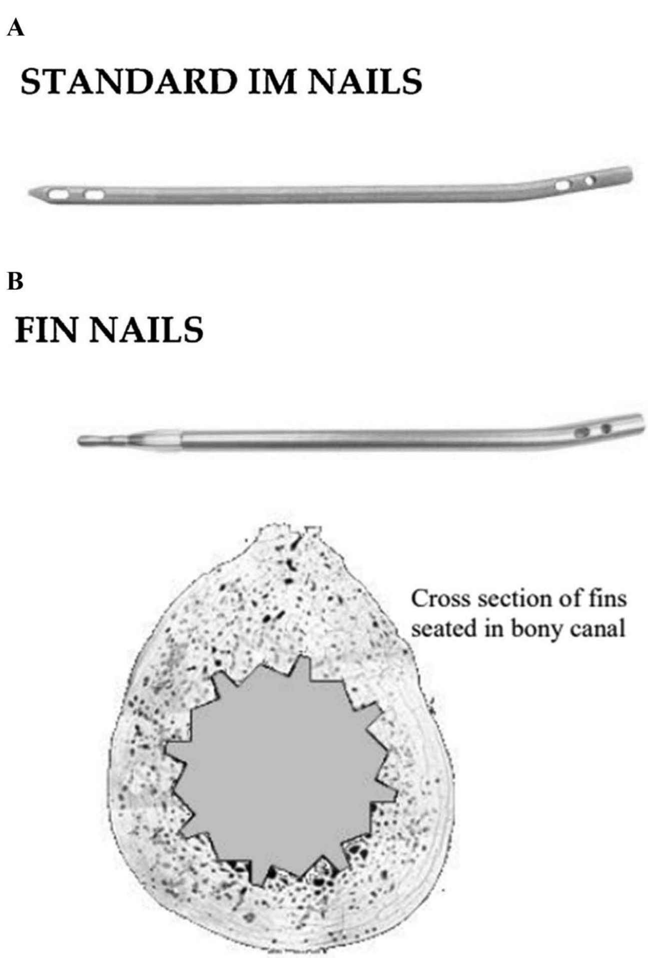

FIGURE 1. SIGN FIN and standard nail.

TABLE 1

Overview of Radiographic Union Scale in Tibial Fracture (RUST)

Score per Cortex	Callus	Fracture Line
1	Absent	Visible
2	Present	Visible
3	Present	Invisible

2.1.2. Specific Objectives. To determine the Johner and Wruhs score.

To determine the RUST score at the final follow-up.

To assess common complications after SIGN FIN nailing of tibial fractures.

2.2. Study Area

Addis Ababa Burn Emergency and Trauma Hospital (AaBET Hospital), a major trauma center in Addis Ababa, Ethiopia, was established in 2015 as part of St. Paul millennium medical college. AaBET currently provides health care services in specialties, namely orthopaedics, neurosurgery, plastic and reconstructive surgery, and emergency and critical care. AaBET hospital has approximately 20,000–30,000 emergency visits/year to the hospital and provides emergency and outpatient services and elective and emergency surgeries by the respective departments. The orthopaedics and trauma surgery department provides outpatient service, emergency, and elective surgeries. It gives fracture care, including complex acetabular and pelvic injuries.

2.3. Study Design and Study Period

We conducted a retrospective case series to assess the outcome of patients with tibial fractures treated with SIGN FIN nail from September 2015 to September 2020.

2.4. Study Variables

Demographic data such as age and sex are included. The pattern of fracture, mechanism of trauma, fracture reduction, associated injuries, comorbid conditions, presurgery antibiotics, size of the nail, and the number of screws used were retrieved from the online SIGN database and patient chart. Radiologic union (RUST SCORE) was calculated from the most recent x rays (Table 1). Patient outcome was assessed according to the Johner and Wruhs criteria (Table 2). Complications such as infection, anterior knee pain, shortening, and rotational deformities were also assessed.

TABLE 2

Johner and Wruhs Criteria With Modification

Criteria	Excellent	Good	Fair	Poor
Nonunion/infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus/valgus	None	2–50	6–100	>100
Anterior/posterior	0–50	6–100	11–200	>200
Shortening	0–5 mm	6–10 mm	11–20 mm	>20 mm
Mobility				
Knee	Full	>90%	90%–75%	<75%
Ankle	Full	>75%	75%–50%	<50%
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limb	Significant limb

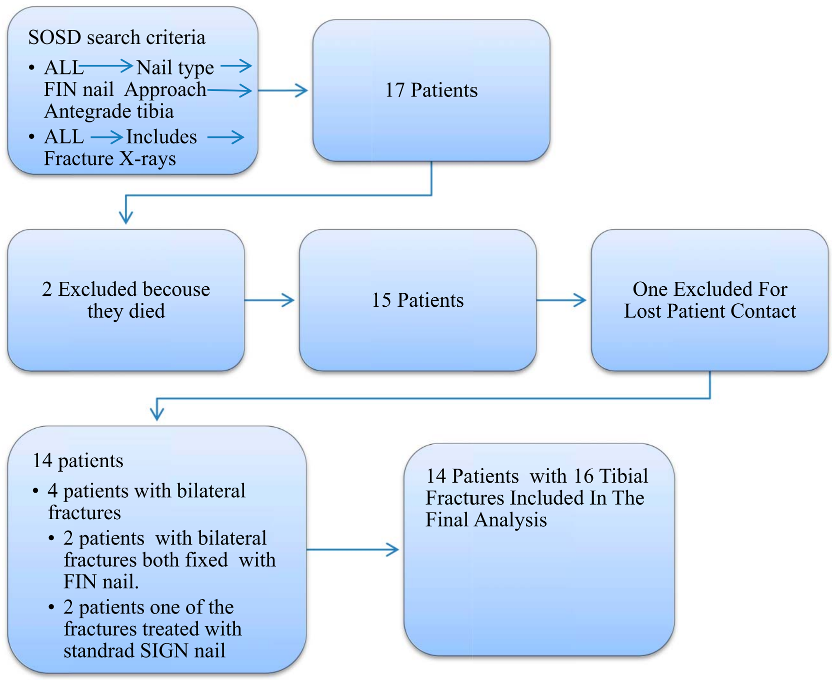

FIGURE 2. Patient selection flowchart.

2.5. Data Collection Tools and Procedures

For this study, we used the SIGN online surgical database (SOSD). The SOSD was retrospectively used to identify all patients who sustained tibial shaft fracture treated with an antegrade SIGN FIN nail performed at AaBET hospital. Patients were excluded if they did not have a minimum follow-up of at least 6 months (with radiographs) or if the patient was not willing or not accessible for evaluation.

We identified 17 patients with tibial fractures which were treated with SIG FIN nail. We excluded three patients. Two patients were dead: one because of his injuries and the other because of second trauma after 2 years of his initial injury. For the other patient, we could not find his contact (Fig. 2).

Patient demographics, injury mechanisms, surgical procedures, and postoperative complications were collected. Details of the

TABLE 3

Fracture Characteristics and Intraoperative Factors

Patient #	Age/Sex	MOI	Classification		Associated Injuries	Trauma to Surgery Time	DOS	Nail Size	
			OTA/42	GA				Diameter (mm)	Length (cm)
1									
Right	40/M	RTA	B3.3	Closed	Tile B pelvic ring injury	5 days	4 hours*	9	32
Left			B2.1	IIIA				9	32
2	30/M	RTA	A3.1	II	Ipsilateral femur shaft fracture, left open distal humerus fracture	5 hours	120 min*	9	32
3	51/M	RTA	A3.3	II	Isolated	5 days	30 min	9	32
4	30/M	RTA	A3.1	Closed	Isolated	4 days	60 min	10	28
5	30/F	RTA	A2.2	I	Right posterior hip dislocation	5 hours	55 min	9	28
6	35/M	Assault	B2.3	Closed		5 days	50 min	9	28
8	20/F	MVA	A3.1	IIIA	Bilateral lung contusions	12 days	60 min		
9	26/M	RTA	A3.1	Closed	Contralateral tibial fracture†	1 day	130 min*	10	32
10	22/M	Assault	A3.1	Closed	Contralateral tibial fracture‡	10 hours	200 min*	8	32
11									
Right		40/M	RTA	C2.1	Closed	Isolated	5 hours	100 min*	9
Left				B2.2	II				9
12	23/M	RTA	A2.2	II	Pelvic ring injury, brain contusion, ASIA E SCI, C2 fracture	42 days	150 min*	10	28
13	37/M	RTA	C2.2	IIIA	Isolated	23 days	150 min	9	28
14	36/F	FDA	A2.1	Closed	Isolated	3 days	40 min	9	28

DOS, duration of surgery; GA Gustilo-Anderson classification of open fractures.
* Durations of surgery including fixations of all fractures.
† External fixator was applied for the contralateral tibia which was later changed to Standard SIGN nail and achieved union.
‡ Standard SIGN nail was used for the contralateral side which developed nonunion, and nail exchange with bone graft was performed.

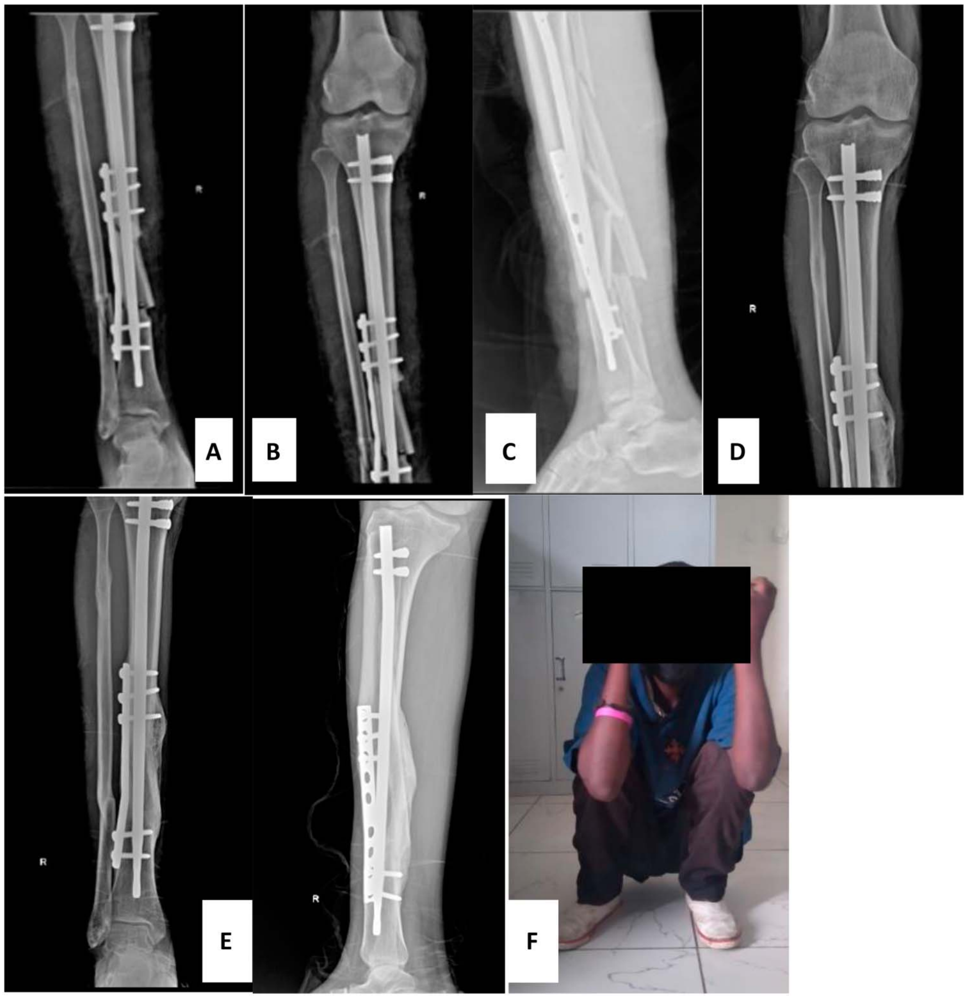

FIGURE 3. Immediate postoperative x-ray of patient with right side AO 42C2.2 open tibial fracture treated with tibial FIN nail augmented with LCDCP plate (A–C). Fracture united on radiographs after 15 months (D and E) and patient with excellent knee flexion (F).

surgical procedure included time from injury to surgical fixation, reduction technique (open or closed), and the size of the implant.

We reviewed radiographs to determine fracture classification, radiographic evidence of healing, and to assess deformity. RUST (radiologic union score for tibia) score was used to evaluate radiologic union.[16,17] Fractures were classified by AO/OTA classification, which separates fractures into three basic types: simple fractures (type A), wedge fractures (type B), and complex fractures (type C) and open versus closed. The open fractures are described according to the Gustilo Andersen classification.[18,19] Immediate postoperative and follow-up images were evaluated for coronal and sagittal plane alignment. Clinical outcome measures included painless weight bearing, RUST score, shortening, rotational deformities, and Johner and Wruhs criteria (Table 2). Malunion or nonunion and any postoperative complications were assessed. A malunion was defined as greater than 5 degrees of angulation in any plane. A nounion was defined as lack of radiologic progression after 6 months–9 months. Deep wound infection is infection that required surgical debridement for a purulent wound or osteomyelitis and treatment with a course of antibiotics.

We evaluated both knees and ankles for range of motion and crepitus. Both knees were evaluated for points of tenderness about the knee: at the medial joint line, lateral joint line, popliteal fossa, patellar articular surface, patellar tendon, and tibial tubercle. The latter 3 areas were considered the "anterior knee."[20] We measured both legs for true leg length, from the anterior superior iliac spine to medial malleolus. The neurologic status of both lower extremities was evaluated by motor power (0–5) in all muscle groups and sensation (2 normal, 1 decreased/abnormal, and 0 none) in all peripheral nerve distributions of the lower leg and foot. Vascularity was evaluated by capillary refill ($1 < 5$, 2, and < 2 seconds) and pulses (2 normal, 1 decreased, and 0 not palpable). Thigh foot angle was measured in both limbs to assess rotational deformities. Greater than 10-degree difference was taken as the presence of deformity, and if both limbs were injured, negative 5 to positive 30 degrees of torsion were used as the normal range.[21]

2.6. Operational Definition

1. Tibial shaft fracture: fractures excluding within 5 cm of the ankle and knee joint.
2. Incomplete follow-up: patient followed for less than 6 months postsurgery or patient who is not contacted during the data collection period.
3. Radiographic union: RUST score of 9 and above.
4. Nonunion: lack of radiologic progression after 6 months–9 months.

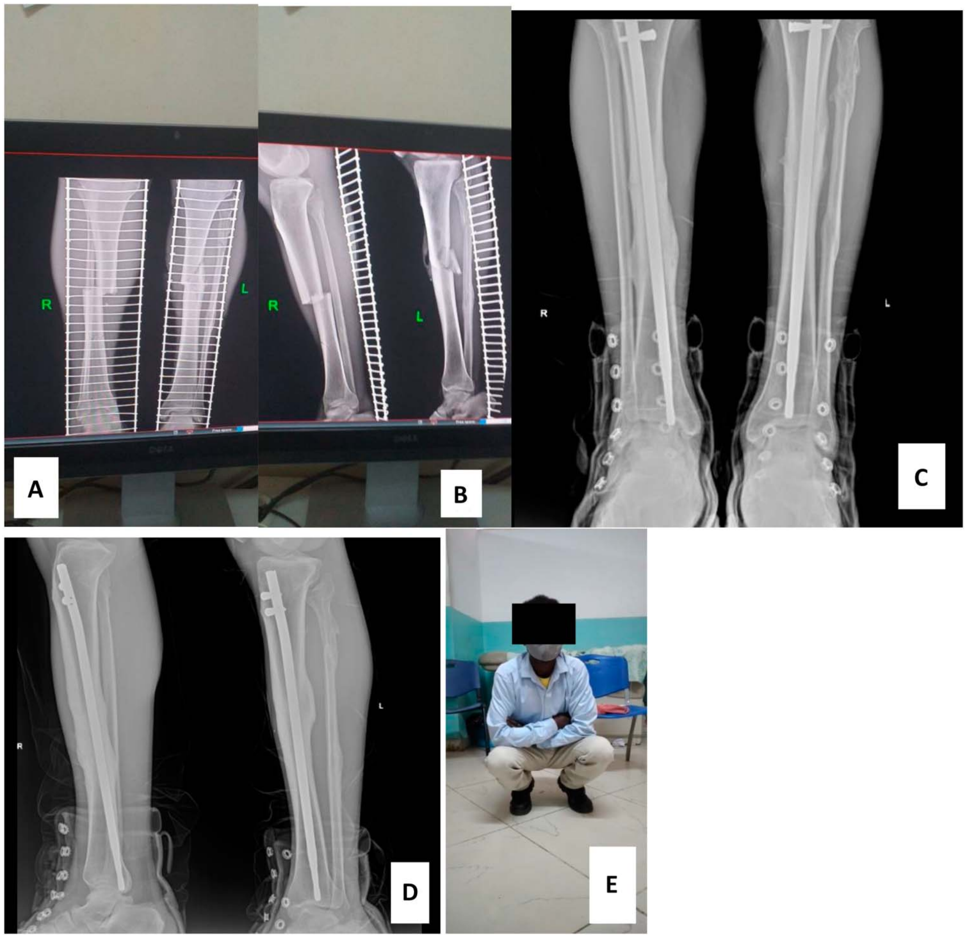

FIGURE 4. Demonstration of clinical and radiographic healing after bilateral tibial shaft fractures in a 40-year-old man treated with SIGN FIN nail. X-ray shows both preoperative (A and B) fractures completely healed (C and D). Clinical picture showing good knee flexion (E).

5. RUST score: radiographic scoring systems designed to enable identification of union in tibias. It has a minimum score of 4 and a maximum of 12. A score of 12 means complete union.[16,17] Bridging callus on at least 3 cortices with fracture line not visible (RUST of 9) was used to define radiologic union.
6. Johner and Wruhs criteria: clinical scoring was done according to Johner and Wruhs score which was completed by the principal investigator. It is a good clinical predictor of return to preinjury activity.[22–24]
7. Painless weight bearing: able to walk with no walking aid with no or minimal discomfort.
8. Implant failure: breakage of the proximal screws, bent or broken nail without fracture healing.

2.7. Data Quality

Collected data were checked for accuracy and completeness. All measurements, knee range of motion (ROM), ankle ROM, limb length discrepancy/leg length discrepancy (LLD), and thigh foot angle (TFA), were taken twice, and the average was taken. A frequency table of all variables was made to check for outliers. The outliers were typing errors and were corrected.

2.8. Statistical Analysis

Statistical analysis was performed using SPSS version 26 Data Analysis and Statistical Software. Demographic characteristics are reported with percentages and means for continuous variables. Statistical significance was assumed at the $P < 0.05$ level. The one-sample *t* test was used to see whether there is a significant difference in the mean value of knee and ankle ROM between normal and injured limbs.

2.9. Ethical Considerations

We were given the ethical clearance from the Institutional Review Board. We obtained written informed consent from each patient. Clinical images were used without mentioning their identity and faces blurred.

3. Results

Fourteen patients with 16 tibial fractures were included in this study. There were 11 male (78.6%) and three female (21.4%) patients. The mean age was 32.44 ± 8.98 (range 18–51) years. The right-sided tibia was injured in six as compared with the left side in four, and four patients had bilateral injuries. Most common mechanism of injury was road traffic accident (n = 11;

TABLE 4

Patient Follow-Up and Outcomes After Surgical Fixation

Patient #	Cxs	FU(Mo)	RTW	ROM		Deformity		TFA		JWC	LLM
				Knee EX/FX	Ankle DF/PF	Val/Var	Pro/Recu	Value	DIF		
1											
Right, Inj	N	21	Y	8/136	9/32	0/2	0/2	42	12 ER	EXCEL	90
Left, Inj	N			0/132	11/42	0/0	0/0	30		EXCEL	91
2											
Right, Inj	N	16	Y	2/110	10/50	0/2	0/0	43	9 ER	GOOD	77
Left, Contr				5/130	20/50			34			78
3											
Right, Inj	N	18	Y	0/130	9/40	0/0	0/0	24	20 IR	EXCEL	78
Left, Contra				0/140	11/40			44			78
4											
Left, Inj	N	20	Y	0/140	9/43	0/2	0/1	50	18 ER	EXCEL	84
Right, Contra				0/130	18/50			32			84
5											
Left, Inj	N	6	Y	5/132	10/40	0/0	0/0	33	3 ER	EXCEL	80
Right, Contra				7/137	12/45			30			80
6											
Right, Inj	N	25	Y	7/135	5/40	0/0	0/0	25	15 IR	EXCEL	90
Left, Contra				6/140	6/50			40			91
7											
Right, Inj	N	16	Y	8/135	0/40	0/0	0/0	52	12 ER	EXCEL	80
Left, Contra				10/145	10/50			40			80
8											
Right, Inj	N	22	Y	10/130	10/40	6/0	2/0	48	12 ER	GOOD	92
Left, Inj*				0/126	10/40			36		FAIR	90
9											
Right, Inj	Y†	9	N†	8/135	10/45	0/0	0/0	25	4 ER	EXCEL	86
Left, Inj	N			8/130	5/40			21		POOR	87
10											
Right, Inj	Y‡	24	Y	4/134	8/38	8/0	0/6	23	11 IR	FAIR	84
Left, Inj	N			3/138	8/50	0/0	2/0	34		GOOD	84.5
11											
Right, Inj	N	9	N§	0/132	0/40	0/3	1/0	31	9 ER	GOOD	83
Left, Contra				2/135	8/46			22			85
12											
Left, Inj	N	29	Y	0/130	0/30	0/0	3/0	40	10 IR	EXCEL	83
Right, Contra				0/130	4/40			50			83
13											
Right, Inj	SSI¶	15	N¶	0/136	0/40	3.6/0	4.8/0	38.2	5.7 ER	FAIR	83
Left, Contra				4/138	10/54			32.5			85
14											
Left, Inj	N	22	Y	10/148	6/45	0.6/0	0/0	34.9	1.3 IR	EXCEL	94
Right, Contra				0/150	8/48			36.2			93

Contra = contralateral normal limb; CXS = complications; DF = dorsi flexion; DIF = side to side difference; EXCEL = excellent; EX = extension; ER = external rotation; FX = flexion; FU = follow-up; Inj = injured limb; IR = internal rotation; JWC = Johner and Wruhs criteria; LLM = limb length measurement ASIS to medial malleolus; N = none; PF = plantar flexion; pro = procurvatum; Recu = recurvatum; RTW = return to work; ROM = range of motion; SSI = surgical site infection; TFA = thigh foot angle; Val = valgus; Var = varus.

* Patient had bilateral tibial fracture and left side was initially managed with external fixator and later changed to standard SIGN nail and bone graft.

† Patient had bilateral tibial fractures, and left side was managed with standard SIGN nail which developed nonunion, and patient had persistent pain at the fracture site preventing him from attending school, but the left tibia had healed uneventfully.

‡ Patient with bilateral tibial fracture both fractures treated with FIN nail, and both fractures had healed, but on the right side, the tip of the nail has migrated to the ankle joint causing ankle pain and limiting ankle ROM.

§ This patient was a university student who had associated ASIA E spinal injury and pelvic ring injury which prevented him from starting school.

¶ This patient was unemployed, but he has no difficulty in moving around. He had superficial infection which healed with oral antibiotics and wound care.

78.6%), followed by assault or violence (n = 2; 14.3%) and fall (n = 1; 7.1%). Eight (50%) fractures had a closed type of fracture, while 8 (50%) patients had an open type of fracture. Among the latter, half (n = 4; 50%) of the fractures were Gustilo type II fractures, while 3 (37.5%) fractures were Gustilo type III fractures, and one (12.5%) patient had a Gustilo type I fracture. Nearly half (n = 9; 56.2%) of the fractures were isolated tibial fractures.

Most of the fractures were at the junction of the lower third and middle third or within the middle third (N = 16; n = 12; 75%); two (12.5%) fractures were in the proximal third, and the remaining two (12.5%) fractures were in the distal third. Fracture types according to the AO/OTA classification, mostly were type A (N = 16; n = 10; 62.7%), type B accounted for 25% (N = 16; n = 4; 25%), and the remaining two patients had complex type C fractures. Five patients (35.7%) had associated injuries, one patient had a floating knee with ipsilateral femur shaft fracture and distal humerus fracture, one patient had a posterior hip dislocation, and the others had pelvic ring injuries and AISA E spinal cord injury (SCI) and blunt chest injuries. Demographic data, fracture characteristics, and intraoperative factors are listed in Table 3.

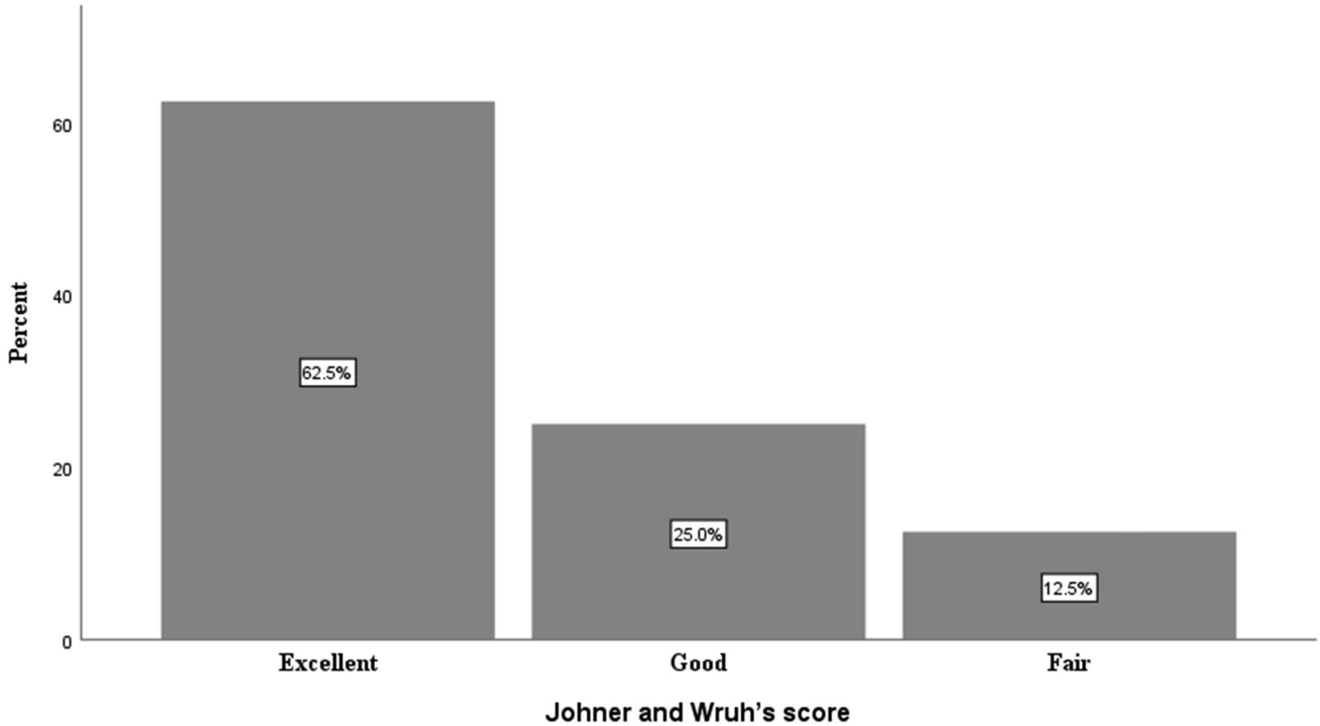

FIGURE 5. Functional results of patients at the last follow-up measured by the Johner and Wruhs criteria.

Almost all the closed fractures (n = 7; 43.8%) were reduced closed without opening the fracture site except in one patient, and in all cases, we used hand reaming. The mean time from injury to surgery was 8.16 ± 11.7 (range 0–42) days. The mean time the surgery took was 111.56 ± 68.88 (range 30–240) minutes.

All open fractures were started with IV antibiotics, and the meantime for initiation of IV antibiotics was 14.38 ± 11.35 (range 1–28) hours. The mean duration of hospital stay was 8.5 (range 3–29) days. The length of nails used was between 280 and 320 mm, and two screws were used in all patients except one patient in which one screw was used in the dynamic hole. In one patient with a complex fracture pattern (AO/OTA 42C2.2), an LCDCP plate was used in addition to the nail, and the fracture healed completely with 3-cm shortening (Fig. 3). We applied a posterior slab for six (37.5%) fractures, and it was performed for fractures with rotational instability which was tested intraoperatively after fixation. The posterior slab was continued for a mean time of 5.17 ± 2.85 (range 2–10) weeks. In the rest of the cases, weight bearing, as tolerated, was started with crutches immediately. The mean follow-up time was 18.56 ± 6.44 months.[6–30]

All fractures healed radiologically with the mean RUST score of 11.75 ± 0.77 (range 9–12). Painless weight bearing was achieved 10.44 ± 2.8 (range 6–16) weeks. One patient had a superficial postoperative infection, which was treated with oral antibiotics and wound care without needing surgery. No patients had repeat surgery for any reason.

No implant failure was noted, but there was one patient with the nail that migrated into the ankle joint (Fig. 4).There were no cases of nonunion noted. In patients having unilateral injury, four patients had LLD of 1 cm and two patients each had 2 and 3-cm shortening on the injured side. During the physical examination for tenderness around the affected and contralateral knee at six sites, only one (6.3%) patient had anterior knee pain and had tenderness at only the anterior knee.

Rotational deformities were assessed by measuring the thigh foot angle and compared with the contralateral uninjured side. Among 10 patients with unilateral injury, four (40%) had side to side difference of the TFA more than 10 degrees, two (20%) patients had external rotation deformity of 12 degrees and 18 degrees, and an additional two (20%) patients had internal rotation deformity of 16 degrees and 20 degrees. In the remaining four patients with bilateral injuries, the mean TFA on one side (right) was 33.16 degrees ± 12.08 degrees (range 21 degrees–48 degrees) and 31.5 degrees ± 3.98 degrees (range 25 degrees–36 degrees) on the other side (left).

Two patients had a valgus deformity, 6 degrees and 8 degrees; one patient had a procurvatum deformity of 6 degrees. The follow-up and outcomes of each case are presented in Table 4.

The one-sample *t* test was performed to determine whether the mean value of knee flexion, extension, ankle dorsiflexion, and plantar flexion was significantly different from the mean value of the normal uninjured limb. The mean knee flexion and hyperextension were 138.6 degrees and 4.7 degrees, respectively, in the normal limb. The result indicates that there was no significant difference in the knee flexion value (M = 132.3, SD = 9.37) and 138.6, t (9) = −2.12, $P = 0.062$. The 95% confidence interval (CI) for the mean knee flexion was −13.0 to 0.4. From the result, we see that the knee flexion on the injured limb is not different from the normal side. For knee extension, there was significant difference in the value (M = 2.2, SD = 3.22) and 4.7, t (9) = −2.45, $P = 0.032$. The 95% CI for the mean knee extension was −4.81 to −0.19. This shows that knee hyperextension was significantly reduced in the injured limb.

For the ankle ROM, the same procedure was followed, and the mean ankle dorsiflexion and plantar flexion were 10.7 and 47.3, respectively, on the uninjured side. The result shows that there is a significant difference in the ankle dorsiflexion value (M = 4.9, SD = 4.5) and 10.7, t (9) = −4.06, $P = 0.003$. The 95% CI for the mean ankle dorsiflexion was −9.02 to −2.58. From the result, we see that the ankle dorsiflexion on the injured limb is significantly reduced when compared with the

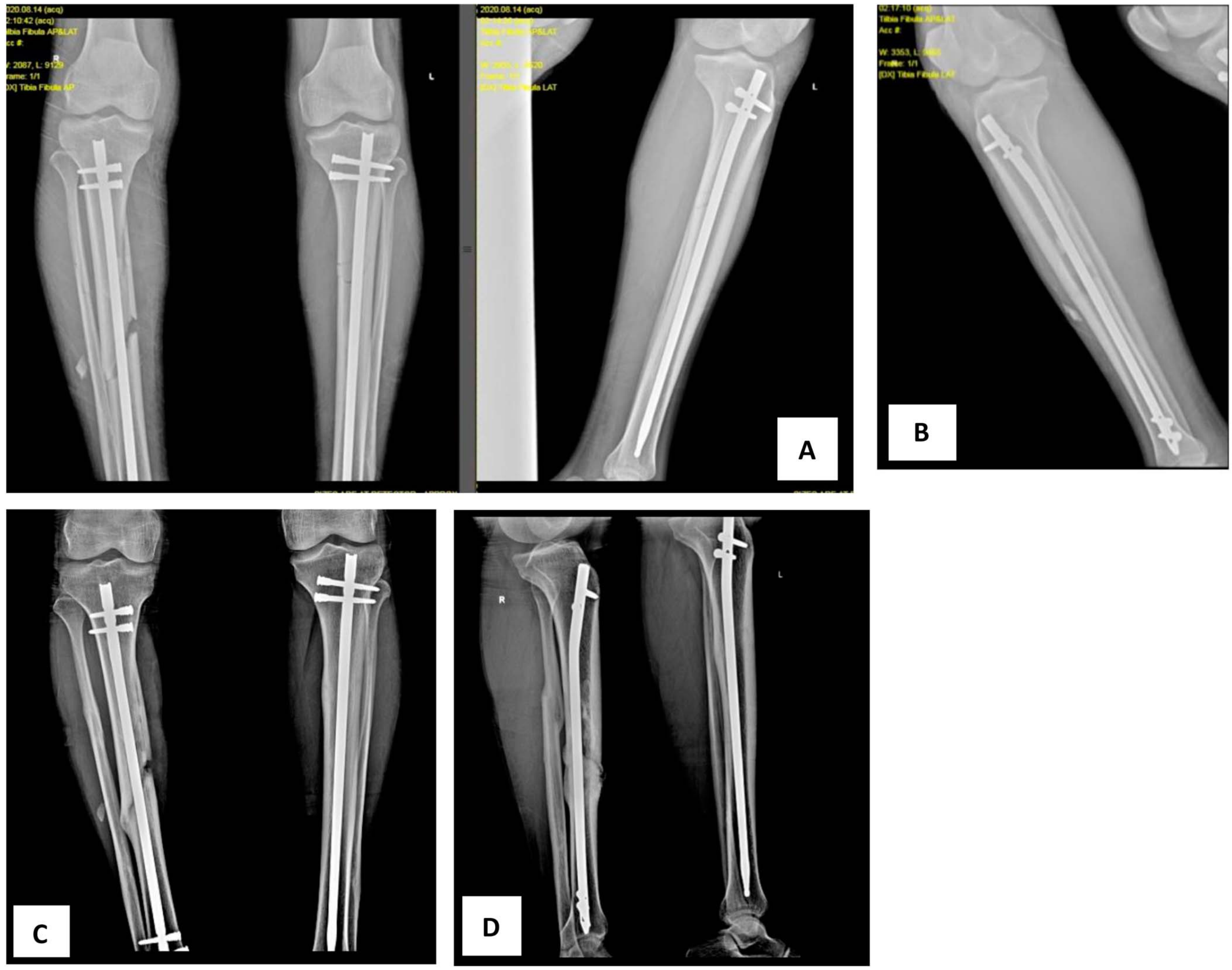

FIGURE 6. Postoperative x-ray of patient with bilateral tibial fractures managed on the right side with standard SIGN nail and left side with FIN nail (A and B). X-ray of the above patient after 9 months of treatment showing complete radiologic union of the tibia treated with FIN nail (C and D).

normal side. In the ankle plantar flexion, there is significant difference in the value (M = 39.8, SD = 3.85) and 47.3, $t(9) = -6.15$, $P < 0.001$. The 95% CI for the mean knee flexion was −10.26 to −4.74. This shows that ankle plantar flexion on the injured side is significantly lower than the normal side.

In the majority, excellent or good outcome was achieved in 87.5% of the cases, measured by the modified Johner and Wruhs criteria (Fig. 5).

All patients have returned to their preinjury job except two patients. Both patients had bilateral fractures. In one of the cases, the contralateral tibial fracture was treated with a standard SIGN nail which developed nonunion (Fig. 6). Similarly, the other one had bilateral fractures, and the contralateral tibial fracture was treated with an external fixator which was later changed to a standard SIGN nail and did not achieve union at the time of final follow-up.

4. Discussion

We used FIN nail for patients with tibial shaft fractures. The FIN nail has external flutes that are designed to fit tightly in the endosteum of the medullary canal isthmus and provide resistance to torsion of the fragment around the nail and relative to the proximal fragment.

In this study, 14 (87.5%) fractures achieved excellent or good outcomes, which is higher than other studies which used the Johner and Wruhs criteria to report outcome.

Batta et al[23] reported 70.6% of the patients had either excellent or good outcome. Similarly Ali Akhtar et al[22] reported the outcome of 30 patients with closed tibial fractures and excellent or good results in 76.6% of patients. Nascimento et al[25] performed their study on 30 patients, and the outcome was almost similar (76.7% had good or excellent outcome).

The mean duration of surgery in this series was 63.57 minutes (30–150 minutes) excluding those with associated other injuries and bilateral injuries because surgery time documented was of total duration. This time is slightly lower than that recorded for locked nails.[28–30]

In this study, there was only one patient with anterior knee pain and tenderness, but anterior knee pain was one of the commonly listed complications of antegrade nailing with a reported incidence of 31%–69%.[31]

In this series, there was only one patient with significant limb shortening. This patient had a complex fracture pattern for which acute shortening with plate augmentation was performed due to the fracture communition. There is a paucity of literature reporting on LLD after intramedullary nailing of tibial fractures. Lefaivre et al[20] reported that there were no significant (greater than 2.5 cm) leg length discrepancies in their patient population.

One advantage of early fixation is the ability for early range of motion of both knee and ankle. Authors have shown a loss of knee range of motion in the early postoperative period and a 10-degree loss of ankle range of motion at 33 months.[32,33] Lefaivre et al[20] that reported there is no difference in knee ROM, but there was a loss of ankle range of motion, ranging from 5 to more than 20 degrees. In this study, there was a similar result with both ankle dorsiflexion and plantar flexion significantly lower than the normal side with a one-sample *t* test. The mean loss of ankle arc of motion was 14–18 degrees. We do not know the long-term effect of this decreased ankle ROM, but it does not seem to affect the early outcome of patients, so we need long-term follow-up.

Rotational deformities were assessed by measuring the thigh foot angle. Two patients had external rotation deformity of 12 degrees and 18 degrees; an additional two (20%) patients had internal rotation deformity of 16 degrees and 20 degrees. The prevalence of rotational malreduction after tibial IMN has been reported to range from 0% to 6% in older clinical studies[34,35] and has been reported to be >19%–36% when measured by CT in recent literature.[21,36] Although we used TFA to asses' rotational deformities which underestimate the deformity, as observed from this series, FIN nail does not seem to increase the risk of rotational deformities when compared with locked nails.

The limitations of this study include small sample size and retrospective study design, and it was performed in a resource limited area where there are scarce implants and no C-arm. Using this study as a baseline, we need a strong evidence study and prospective cohort or case–control studies to compare the outcome of standard SIGN nail and FIN nail.

5. Conclusion and Recommendation

In this study, all patients had radiologic union and most patients had excellent or good functional scores without major complications. All patients were able to return to their preinjury activity except two. The FIN nail could be one option of treating tibial fractures without increased risk of complications in selected fractures. Fractures which are length unstable and distal 1/3rd fractures should be avoided. Nail diameter should be determined from preoperative x rays, and the diameter should be at least the size of the isthmus to avoid postoperative splint application.

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