ORIGINAL RESEARCH

Gradual Correction of Valgus Deformities of the Tibia Using a Monolateral External Fixator

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Abstract

Objective: To present a review of patients subjected to gradual correction of a valgus deformity of the tibia using a monolateral external fixator.

Method: This retrospective review included patients from January 2012 to May 2022 who met the following inclusion criteria: deviation of mechanical axis of the limb due to valgus deformity of the tibia; tibial deformity in the coronal plane on radiographic examination; a documented outpatient pre-operative evaluation by an orthopaedic surgeon and age between 10 and 70 years. The following exclusion criteria were applied: the presence of another tibia deformity preventing gradual correction using the proposed assembly; skin conditions incompatible with the surgical procedure; inadequate pre- or post-operative radiological evaluation; and insufficient information in the medical records.

Results: The mean age of patients with a valgus deformity of the tibia was 30.8 ± 15.9 years. These patients had a body mass index (BMI) of 26.1 ± 5.5 kg/m^2. A congenital or developmental aetiology was attributed to 58.3% of the cases. Most commonly, the deformity was found in the middle third of the tibia with a mean deformity of 14.7 ± 6.6 degrees. The total external fixator time ranged from 73 to 229 days (average 149.7 ± 36.1 days). The mean medial proximal and lateral distal tibial angles differed significantly for pre- and post-operative measurements ($p \leq 0.05$). There were complications in eight cases; five cases of pin site infections, two cases of medial cortical fracture and one case of peroneal nerve neuropraxia.

Conclusion: The proposed correction technique produces a satisfactory angular correction and with similar outcomes as described in the literature.

Keywords: External fixation, Monolateral, Osteotomy, Tibia deformity, Valgus.

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Introduction

Lower-limb deformities generate biomechanical changes in the joints and potentially accelerate a degenerative process and decrease the quality of life.[1] The underlying aetiologies can be classed into congenital, developmental or post-traumatic, including deformities arising after surgery for lower limb long bone fractures, physeal arrests and changes from the conservative treatment of fractures.[2–4]

Pre-operative planning should involve evaluation in the coronal, sagittal and axial planes as deformities can be present in more than one plane. The radiographic assessment for deformity analysis and correction planning is a key step; it is possible to determine the type, magnitude and position of one or more apexes of the deformity from this assessment.[5,6]

Deformities located in the coronal plane of the tibia, more specifically valgus deformities, can be corrected using different approaches. However, these surgeries are unfamiliar due to the low incidence of valgus deformities in the population, the limited number of orthopaedic surgeons with such expertise, few published studies on valgus deformities of the tibia and its biomechanical alterations, a relative scarcity of specific implants for osteotomies of the proximal and distal metaphyseal regions and the possibility of complications, such as peroneal nerve neuropraxia.[7–11]

The aim is to present a retrospective review of patients subjected to gradual correction of a valgus deformity of the tibia through a lateral open-wedge by means of a monolateral external fixator.

Method

This series of patients were treated at the National Institute of Traumatology and Orthopedics (*Instituto Nacional de Traumatologia e Ortopedia* – INTO) of the Unified Health System (SUS), in Rio de Janeiro, from January 2012 to May 2022. This study was approved by the Research Ethics Committee (*Comitê de Ética em Pesquisa* – CEP) under the Ethical Approval Certificate (*Certificado de Apresentação de Apreciação Ética* – CAAE) opinion 55422022.6.0000.5273 of April 2022.

The following inclusion criteria were used for this study: (1) deviation of the mechanical axis due to valgus deformity of the tibia; (2) a tibial deformity in the coronal plane only on radiographic assessment; (3) documented outpatient pre-operative evaluation

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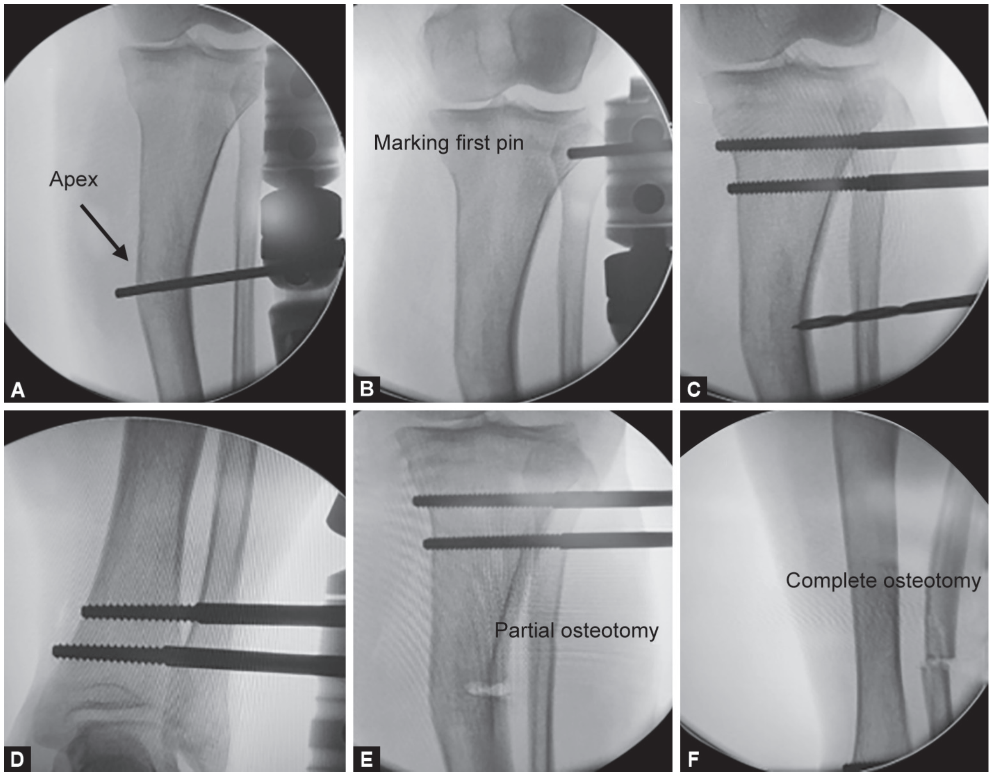


Figs 1A to F: Surgery steps. Images from fluoroscopy (reedited from Motta et al.).[13] (A) Apex of deformity; (B) Marking first pin parallel to articular surface; (C) Two pins on proximal tibia; (D) Two pins on distal tibia; (E) Partial osteotomy of tibia; (F) Complete osteotomy of tibia

by an orthopaedic surgeon from the Specialized Care Centre for the Treatment of Dysmetria and Deformities of the Locomotor Apparatus (*Centro de Atenção Especializada de Tratamento da Dismetria e Deformidades do Aparelho Locomotor* – CAE SEFIX) and (4) age between 10 and 70 years.

The exclusion criteria applied were as follows: (1) the presence of another deformity of the tibia preventing gradual correction using the proposed fixator assembly; (2) skin conditions incompatible with the surgical procedure; (3) inadequate pre- or post-operative radiological evaluation and (4) incomplete information from the medical records.

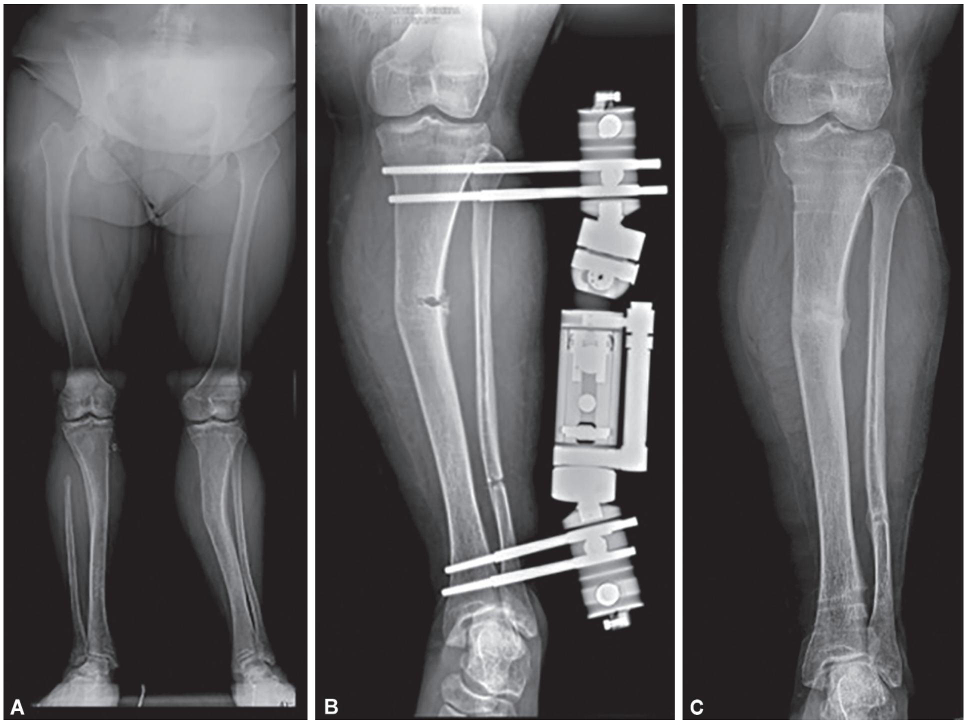
The data collected from medical records were age, ethnicity, marital status, sex, side, date of surgery, date of hospitalisation, date of hospital discharge, date of external fixator removal, complications observed in outpatient follow-up, body mass index (BMI), American Society of Anaesthesiologists classification and comorbidities. After radiographic analysis, the medial proximal tibial angle (MPTA), lateral distal tibial angle (LDTA) and the magnitude of the deformity and the location of its apex were determined and the deformity correction planned according to the method proposed by Paley et al.[12] A comparison of the characteristics of the groups with varus and valgus deformities is also provided.

Surgical Technique

Motta et al.[13] described gradual correction with monolateral external fixation. A small 1-cm percutaneous incision is made in the proximal portion of the tibia with blunt separation of the muscular and subcutaneous planes performed with Metzenbaum scissors until the periosteal surface is reached. Under intraoperative fluoroscopic guidance, a 4.8-mm drill is passed from the anterolateral cortex of the tibia and parallel to the articular surface of the tibial plateau at approximately 2 cm below this surface; a 6-mm conical external fixator half-pin is then inserted across the drill track. A monolateral external fixator with a telescopic self-aligning body and clamps is assembled next. The chosen clamp is placed on the proximal pin, the clamp cover temporarily tightened. Distally, the lower half-pin is inserted after pre-drilling but with care to ensure that the point of the fixator hinge being exactly coincident to the apex of the deformity. When completed, single additional half-pins are inserted with prior pre-drilling in the proximal and distal clamps (Figs 1A to D).

Under fluoroscopic guidance, the apex of the tibial deformity is approached through an anterior incision of approximately 5 cm. The subcutaneous and muscular planes are separated and retracted using two Hohmann-type retractors. Under direct vision, a partial osteotomy (drill and osteotome) is performed leaving the crest of the tibia to the medial cortex intact with the purpose of this preserved portion functioning as a hinge. Access to the fibula is made by an incision placed 10 cm proximal to the lateral malleolus; the osteotomy of the fibula is performed with a 4.8-mm drill to prevent impaction during distraction of the tibia (Figs 1E and F). A distraction unit is added to the fixator body and an Allen key used to perform the distraction by approximately 1 cm. This is then checked by direct visualisation of the focus and under fluoroscopy. Haemostasis is confirmed at both surgical sites prior to wound closure using nylon 2.0 sutures. At the end of the procedure, a baseline post-operative radiograph is obtained as a control (Fig. 2).

On the first post-operative day, each patient is encouraged to walk with the aid of crutches, and placing a load upon the operated



Figs 2A to C: Radiograph pre- and post-operative. (A) Pre-operative; (B) Post-operative; (C) Final radiograph

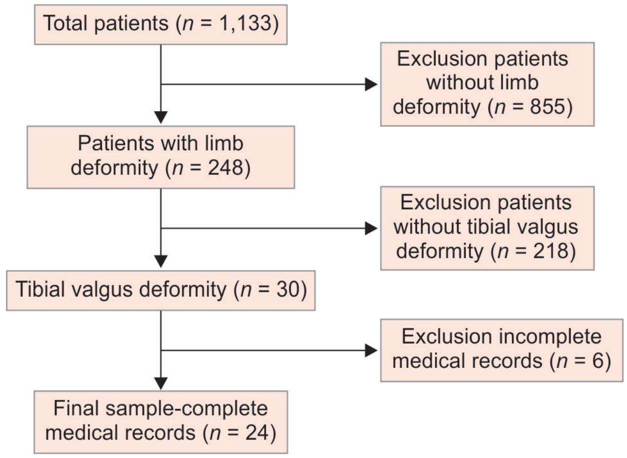
Figs 3A to C: Post-operatives clinical images (from Motta et al.).[13] (A) Pre-operative; (B) 3 weeks post-operative; (C) 5 weeks post-operative

limb is necessary to stimulate bone consolidation and enable the return to daily activities. The total length of hospital stay is usually 3 days. Each participant returns at 14 days postoperatively and is taught how to distract the device (a quarter turn every 6 hours). Distraction begins at 1 mm/day (0.25 mm for each quarter of the distractor unit every 6 hours using the Ilizarov concept) and this rate can be changed according to radiographic progress as assessed at the outpatient follow-up. If new bone is seen on the tibial osteotomy on new radiographs, distraction is maintained at 0.25 mm/day; if not, the rate is slowed to a quarter turn every 8 hours. The patient returns weekly for radiographic monitoring of progress. The patients are encouraged to loaf the limb fully and avoid the use of crutches. The weekly assessments involve clinical examination of the limbs, the radiological progress of the correction, an evaluation of the quantity and quality of bone formation at the osteotomy site, as well as checks on the local skin condition and care of the external fixator. When satisfactory clinical correction is achieved and this is confirmed radiologically (as measured by optimal proximal and distal tibial joint angles on coronal plane radiography), the distraction is paused (Fig. 3). The consolidation phase of the regeneration then commences. In the event over-correction has occurred leading to a varus deformity of the tibia, it is possible to compress the osteotomy through the distractor unit until the correct position is achieved.

Statistical Analysis

The results were presented using descriptive measures, including absolute and relative frequencies, and numerical summaries, such as the minimum, maximum, median and interquartile range and

Flowchart 1: Database search for patients with tibial valgus deformity



mean and standard deviation (SD). The data were analysed by comparing proportions between groups for categorical variables using the chi-square or Fischer's exact (if applicable) tests. The means and medians were compared using the non-parametric Mann–Whitney *U* test and Wilcoxon signed-rank test, respectively. A scatter plot was also constructed to identify the correlations between continuous quantitative variables.

In all statistical tests of this study, statistical differences were considered at a $p \leq 0.05$. Data analysis was performed using SPSS 23.0 (Statistical Package for Science – Chicago, IL, 2008).

Results

A search was performed in the INTO hospital information system with data query using the long-bone osteotomy code of the SUS. Overall, 1133 patients were subjected to surgery at CAE SEFIX of whom 248 had the required code. Only 30 patients had valgus deformity of the tibia, 6 cases were excluded due to incomplete medical reports (Flowchart 1).

On radiographic assessment, 79 patients were identified as having been subjected to gradual correction through an open-wedge tibial osteotomy to correct a deformity in the coronal plane. Among these, 24 (30%) and 55 (70%) patients had valgus and varus deformities, respectively (Table 1).

Most patients subjected to surgery were young adults (age ≥19 years), single, non-Caucasian men with a BMI of >25 kg/m^2. Most had a congenital proximal tibial deformity (Table 1). Significant differences were found between the groups when comparing the two types of deformities in the coronal plane. Patients with valgus deformity of the tibia had a younger mean age (30.8 years; SD = 15.9) than those with a varus deformity (34.1 years; SD = 17.8). Most patients were non-Caucasian, accounting for 60% varus and 70% valgus cases. Valgus and varus cases also differed in the BMI; most patients with a varus deformity were overweight (BMI ≥25 kg/m^2 in 76.4%). Moreover, the patients had at least one comorbidity in most varus and valgus cases (45.8% and 50.9%, respectively, Table 1).

The aetiology was congenital in 14 of the valgus cases (58.3%) and in 39 of the varus cases (70.9%). The apex of deformity was outlined according to the plan proposed by Paley et al.[12] In the valgus and varus group, most deformities were identified in the middle third (79.9%) and proximal third (80%) of the tibia, respectively (Table 1).

Table 1: General characteristics of the study sample for valgus (*n* = 24) and varus (*n* = 55) conditions

Variables	*Valgus n (%)*	*Varus n (%)*	*p-value*
Sex			
Female	11 (45.8)	16 (29.1)	0.19
Male	13 (54.2)	39 (70.9)	
Age (years)			
≤18	5 (20.8)	20 (36.4)	
19–25	7 (29.2)	4 (7.3)	0.03
≥25	12 (50.0)	31 (56.4)	
Ethnicity			
Caucasian	7 (29.2)	22 (40.0)	0.33
Non-caucasian	17 (70.8)	33 (60.0)	
BMI (kg/m^2)			
<18.5	1 (4.2)	2 (3.6)	
18.5–24.9	13 (54.2)	11 (20.0)	0.01
≥25	10 (41.7)	42 (76.4)	
Aetiology			
Congenital	14 (58.3)	39 (70.9)	0.22
Traumatic	10 (41.7)	16 (29.1)	
Deformity site			
Proximal	5 (20.8)	44 (80.0)	
Middle	19 (79.2)	9 (16.4)	0.001
Distal	0 (0.0)	2 (3.6)	
Comorbidities			
Yes	11 (45.8)	28 (50.9)	0.88
No	13 (54.2)	27 (49.1)	
	Mean ± SD	*Mean ± SD*	
Age (years)	30.8 ± 15.9	34.1 ± 17.8	0.55
BMI (kg/m^2)	26.1 ± 5.5	28.8 ± 6.53	0.36

BMI, body mass index; SD, standard deviation

The mean time required for correcting the valgus deformity of the tibia using the proposed external fixator assembly was 149.7 days (SD = 36.1), ranging from 74 to 229 days. The required length of hospital stay for the procedure was 3.1 days (SD = 2.6; Table 2).

Table 2: Clinical characteristics of the study sample for the valgus condition (n = 24)

Parameters	*Mean ± SD (range)*
Length of hospital stay (days)	3.1 ± 2.6 (2–13)
Total fixator time (days)	149.7 ± 36.1 (73–229)
mMPTA (pre-operative degrees)	93.3 ± 6.1 (77–104)
mMPTA (post-operative degrees)	88.2 ± 2.4 (81–91)
mMPTA (difference in degrees)	–5.2 ± 6.1 (–17–9)
mLDTA (pre-operative degrees)	81.7 ± 8.8 (65–98)
mLDTA (post-operative degrees)	89.2 ± 2.9 (83–93)
mLDTA (difference in degrees)	7.2 ± 9.1 (–7–25)
Deformity (degrees)	14.7 ± 6.4 (6–36)

Comparison between angles				
Parameters	*Mean ± SD*	*p-value*	*Median (IQ)*	*p-value*
mMPTA (pre-operative degrees)	93.3 ± 6.1	0.005	96.0 (89.0–98.0)	0.001
mMPTA (post-operative degrees)	88.2 ± 2.4		89.0 (87.0–90.0)	
mLDTA (pre-operative degrees)	81.7 ± 8.8	0.01	83.0 (75.0–88.5)	0.002
mLDTA (post-operative degrees)	89.2 ± 2.9		90.0 (87.0–92.0)	

IQ, Interquartile range; mLDTA, mechanical lateral distal tibial angle; mMPTA, mechanical medial proximal tibial angle; SD, standard deviation

The mean magnitude of the tibial deformity corrected in the valgus group was 14.7° (SD = 6.4, 6–36). The angles measured on radiographs showed alterations in both the medial proximal (MPTA; mean = 93.3°; SD = 6.1) and lateral distal (LDTA; mean = 81.7°; SD = 8.8) tibial angles. The mean MPTA was corrected by 5.2° (SD = 6.1), ranging from 9 to –17°, and the mean LDTA improvement by 7.2° (SD = 9.1), ranging from –7 to 25° (Table 2). Significant differences were found when comparing the pre- and post-operative angles (Table 2).

Distraction osteogenesis following the Ilizarov principles of deformity correction averages 1 mm/day. Therefore, the final distance between bone fragments at the end of deformity correction will determine the total fixator time.[14] This relationship was highlighted by the positive correlation between the total fixator time and degree of deformity in the group with tibial valgus (Fig. 4).

Subcategory analysis by the degree of deformity degree with a cut-off of 12° shows that patients in the subgroup with >12° of deformity were primarily men (63.6%) >25 years, were of a BMI of >25 kg/m^2, had a traumatic aetiology (54.5%), and with the apex of deformity in the middle third of the tibia (63.6) (Table 3).

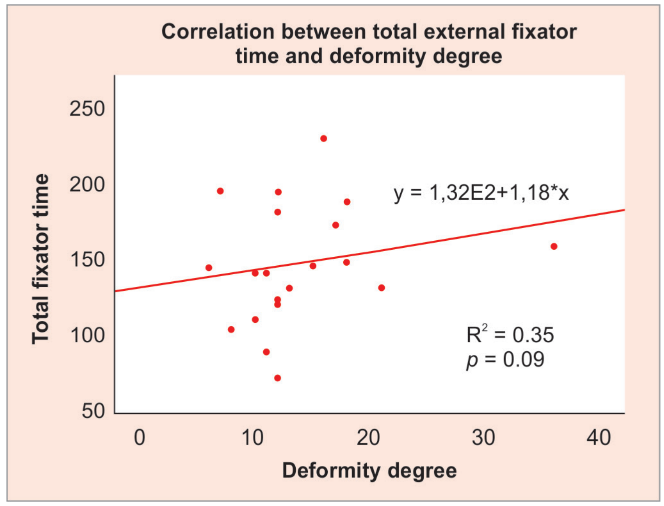


Fig. 4: Correlation between the total external fixator time and degree of deformity

There were eight cases with complications. The main complication was pin-site infection (five cases) which was addressed by outpatient treatment using an oral antibiotic. There were two cases of osteotomy re-fracture and one case of osteotomy fracture and peroneal nerve neuropraxia (Fig. 5).

Patients who presented with complications were mostly non-Caucasian (75%) men (five cases) >25 years, with a BMI of >25 kg/m^2 and at least one comorbidity (75%, significant difference). The deformities differed significantly in location (75%) rather than in aetiology. The mean total time with the monolateral external fixator was longer in patients with complications (mean = 164.5 days; SD = 36.5) than that in those without (mean = 142.4 days; SD = 34.7; Table 4).

Discussion

Patients with lower-limb deformities may require correction to restore the normal position of the mechanical axis and potentially reduce joint wear on the hip, knee or ankle.[10,15,16]

The crucial step is surgical planning which requires detailed outpatient clinical and radiographic evaluations. The physical examination of the patient, particularly the segment to be operated on, is important; the orthopaedic surgeon assesses the patient's functional capacity, possible neurological sequelae and above all, the skin and soft tissue conditions that enable deformity correction surgery.[17] Psychosocial factors also play a key role in the treatment decision-making process. Patients unable to understand the gradual correction process by external fixation or adhere to the post-operative outpatient treatment and follow-up protocol should be considered for acute rather than gradual correction. Radiographic assessments to locate and quantify the nature of the deformity enables the most appropriate surgical approach and orthopaedic fixation method for the case.[12]

Acute correction has the advantage of a single intervention but precludes adjustments in the event of over- or under-correction. Gradual correction uses callotasis (distraction osteogenesis) which can provide patients with a titratable correction in the

Table 3: Assessment of the valgus deformity degree and patient variables ($n = 24$)

	Deformity degree		
	≤12 (n = 13)	*>12 (n = 11)*	*p-value*
Sex			
Female	7 (53.8)	4 (36.4)	0.23
Male	6 (46.2)	7 (63.6)	
Age (years)			
≤18	1 (7.6)	4 (36.4)	
19–25	6 (46.2)	1 (9.1)	0.07
≥25	6 (46.2)	6 (54.5)	
Skin colour			
Caucasian	3 (23.1)	4 (36.4)	0.39
Non-caucasian	10 (76.9)	7 (63.6)	
BMI (kg/m^2)			
<18.5	0 (0.0)	1 (9.1)	
18.5–24.9	9 (69.2)	4 (36.4)	0.20
≥25	4 (30.8)	6 (54.5)	
Aetiology			
Congenital	9 (69.2)	5 (45.5)	0.22
Traumatic	4 (30.8)	6 (54.5)	
Deformity site			
Proximal	1 (7.7)	4 (36.4)	0.11
Medial	12 (92.3)	7 (63.6)	
Comorbidities			
No	8 (61.5)	5 (45.5)	0.43
Yes	5 (38.5)	6 (54.5)	
	Mean (SD)	*Mean (SD)*	
mMPTA (pre-operative degrees)	90.7 (6.4)	96.4 (4.1)	0.02
mMPTA (post-operative degrees)	88.2 (1.8)	88.3 (3.1)	0.86
mLDTA (pre-operative degrees)	84.8 (7.6)	78.1 (9.2)	0.08
mLDTA (post-operative degrees)	89.5 (3.0)	88.9 (2.9)	0.64
Fixator time (in days)	138.9 (39.9)	162.5 (27.4)	0.12

BMI, body mass index; mLDTA, mechanical lateral distal tibial angle; mMPTA, mechanical medial proximal tibial angle; SD, standard deviation

Table 4: Evaluation of complications in valgus and patient variables ($n = 24$)

	Complication		
	No (n = 16)	*Yes (n = 8)*	*p-value*
Sex			
Female	8 (50.0)	3 (37.5)	0.67
Male	8 (50.0)	5 (62.5)	
Age (years)			
≤18	3 (18.8)	2 (25.0)	
19–25	6 (37.5)	1 (12.5)	0.44
≥25	7 (43.8)	5 (62.5)	
Skin colour			
Caucasian	5 (31.3)	2 (25.0)	0.75
Non-caucasian	11 (68.8)	6 (75.0)	
BMI (kg/m^2)			
<18.5	0 (0.0)	1 (12.5)	
18.5–24.9	10 (62.5)	3 (37.5)	0.24
≥25	6 (37.5)	4 (50.0)	
Aetiology			
Congenital	10 (62.5)	4 (50.0)	0.55
Traumatic	6 (37.5)	4 (50.0)	
Deformity site			
Proximal	3 (18.7)	2 (25.0)	0.28
Medial	13 (81.3)	6 (75.0)	
Comorbidities			
No	11 (68.8)	2 (25.0)	0.04
Yes	5 (31.3)	6 (75.0)	
	Mean (SD)	*Mean (SD)*	
mMPTA (pre-operative degrees)	92.1 (6.1)	95.6 (5.7)	0.19
mMPTA (post-operative degrees)	87.8 (2.6)	89.1 (2.1)	0.29
mLDTA (pre-operative degrees)	82.0 (9.3)	81.2 (8.4)	0.84
mLDTA (post-operative degrees)	89.2 (2.9)	89.3 (3.2)	0.96
Fixator time (in days)	142.4 (34.7)	164.5 (36.5)	0.16

BMI, body mass index; mLDTA, mechanical lateral distal tibial angle; mMPTA, mechanical medial proximal tibial angle; SD, standard deviation

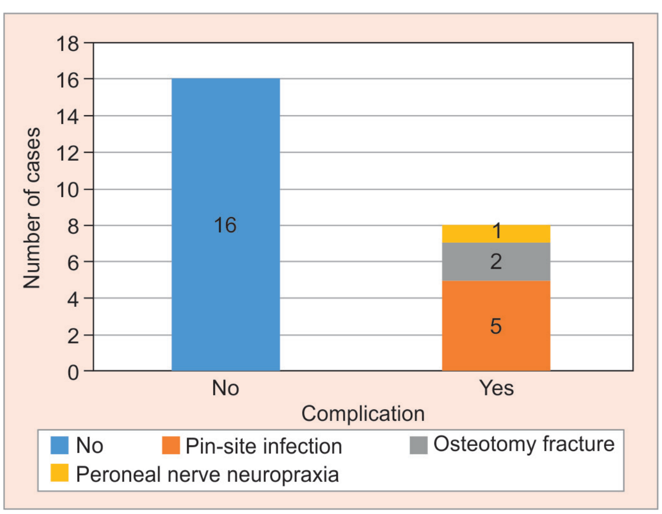
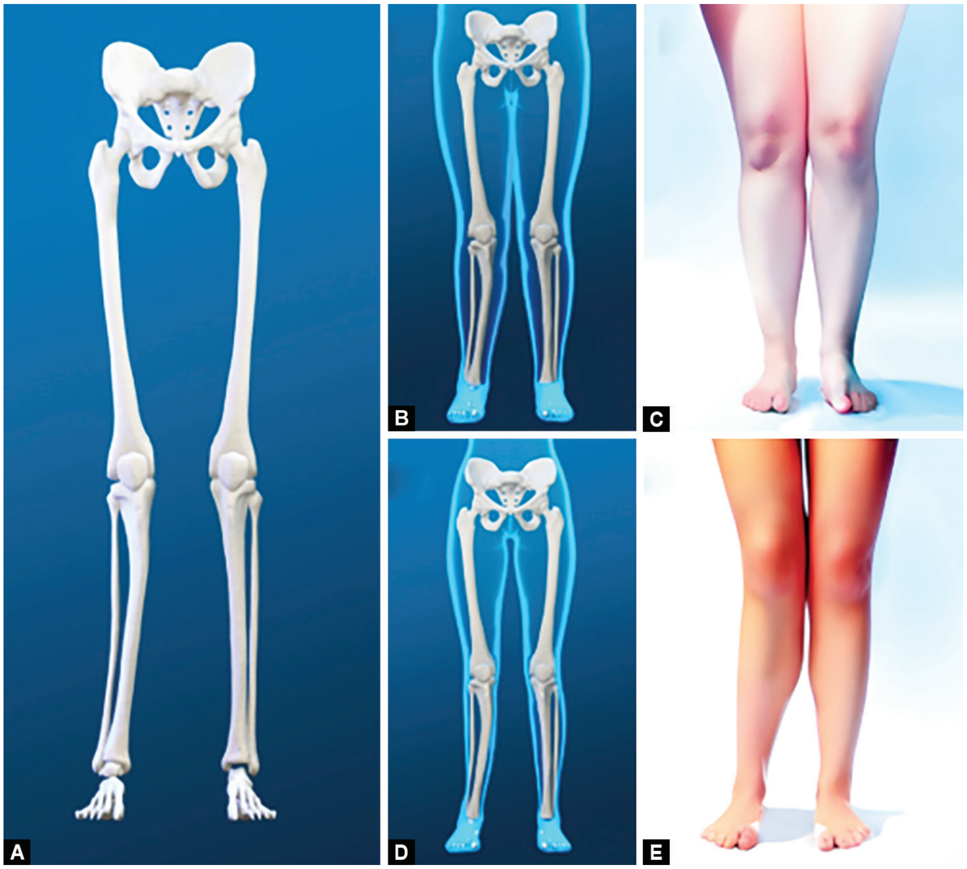


Fig. 5: Complications during the deformity correction process

post-operative period. Nevertheless, acute correction can be performed with most orthopaedic implants, viz., plate and screw systems, locked intramedullary nails or external fixators.[3,8,9,18–23] Gradual correction, in those who still have growth remaining from the physes, can be performed using epiphysiodesis or hemiepiphysiodesis or, in the skeletally mature, with a circular or monolateral external fixator. The ideal age and time for deformity correction is controversial; currently, the multiplier method is the commonly used because it is practical and offers estimated data closer to the real data.[24] Even so outpatient follow-up should be regular to avoid complications with overcorrection.[20–27]

Using an external fixator stabilisation in correction of deformity is a viable option for patients with significant deformities and if the patient is in an age group inappropriate for knee arthroplasty, internal fixation is contraindicated due to a history of infection or there are large changes in bone structure from fracture malunion or numerous previous surgeries. External fixation can be used for both proximal and distal metaphyseal or diaphyseal deformities.[28]



Figs 6A to E: (A) Valgus deformity of the tibia on the right side; (B) Soft tissue contours in the presence of an individual with high volume soft tissue bulk may mask the underlying skeletal deformity especially if the deformity is less than moderate; (C) Clinical illustration of patient in (B) showing this masking effect; (D) Soft tissue contours in the presence of an individual with a slim build and valgus deformity in the tibia; (E) Clinical illustration of patient in (D) Showing loss of this masking effect

There are few published studies of patients with a tibial valgus deformity corrected through a tibial procedure. Most studies generally address the deformity by correcting in a different segment. Peng et al.[10] reported that valgus deformities >12° or with knee joint line obliquity >10° should be corrected in the femoral segment due to the increased risk of lateral tibial subluxation and knee joint instability. Puddu et al.[28] corroborated the previous findings by merely adjusting the aforementioned indication for deformities >10°. However, Al-Saati et al.[29] reported that a lateral opening-wedge high tibial osteotomy should be performed in the tibial segment, regardless of the deformity magnitude. Our clinical experience brings to notice occasions when the impression gained from clinical examination does not coincide with analysis from radiographs. This clinical–radiological dissociation is seen in two circumstances: if there is a patient with increased muscle volume or adipose tissue, this may mask the asymmetry of the lower limb alignment during clinical examination, despite radiologic evidence of a deformity. Conversely, patients with significant scar contractions or decreased soft tissue may display an apparent asymmetry in alignment, despite no deformity being present on radiograph analysis. This clinical–radiological dissociation may contribute to the limited data available on correcting deformities of smaller magnitude (Fig. 6).

A lateral opening osteotomy of the tibia performed gradually with a monolateral external fixator has advantages related to both assembly and surgical technique. The fixator assembly is less cumbersome compared with circular fixators: fewer elements transfix the skin, reducing work with dressings and pain; there is a simple single distraction device (as opposed to six struts with modern hexapods) to induce the gradual correction. The surgical technique itself can be done through minor surgical access, a partial (incomplete) tibial osteotomy, and takes a shorter surgical time over the more elaborate circular external fixator devices.[13]

Post-operative complications can occur with any orthopaedic implant, therefore the technical knowledge to resolve possible complications is as important as the primary surgical procedure. The external fixator utilises half-pins or olive wires or both which transfix the skin. These implants will become covered by a fibrous glycocalyx (biofilm) produced by skin bacteria. These half-pins and olive wires generate inflammation in both the adjacent soft and bony tissues.[30] During the course of treatment, a pin-site infection may occur with extrusion of pus. Kazmers et al.,[31] in their review, cited that patients subjected to gradual correction of deformity have a 2.5 times higher risk of developing a pin-site infection than those who use a static fixator. The percentages of published pin-site infection vary from 0 to 100% of cases.[32] Most patients respond well to the initial oral antibiotic therapy and local care although, rarely, some require surgery for osteomyelitis.[14,15,27,33] The patients in this study who had this complication had the pin-site infections resolved by oral antibiotics and local care only.

A partial tibial osteotomy for the purpose of hemi-callotasis lacks a standard width for the osteotomised area such that it reduces the risk of propagation to a cortical fracture.[15] No study on medial cortical fractures from a partial lateral open-wedge tibial osteotomy has been published. However, in other studies on tibial varus deformities, a lateral cortical fracture was observed in 2 (9%) cases of the total sample (22 patients) when performing gradual correction.[34] Our experience suggests that bone quality, the location and magnitude of the deformity all affect the surgical outcome. Both the bone diameter and plasticity of the tibia are lower in the diaphyseal region than in the metaphyseal region.

In valgus deformity of the tibia, a shortening occurs in the lateral portion of the leg across which the common peroneal nerve traverses at the neck of the fibula. During distraction osteogenesis, the lateral portion of the leg is lengthened relative to the medial with the consequent distraction of the neurovascular structures. Neuropraxia is the most common form of peroneal nerve injury from traction in this mechanism. A systematic review by Puijk et al. indicated a 12-fold increase in the relative risk of peroneal nerve neuropraxia with valgus deformities >12° when performing total knee arthroplasty.[35] Ofiram et al. and Rozbruch et al. reported peroneal nerve neuropraxia in 16% and 2% of cases respectively.[36–38] Nogueira et al. suggest prophylactically performing peroneal nerve neurolysis in deformities of >5°.[38] Should this complication occur, treatment involves medication for neuropathic pain or neurolysis of the common peroneal nerve at the neck of the fibula. Compression of the osteotomy site may also reduce nerve stretching.[28,29,33,39,40]

Specifically for valgus deformities of the tibia, Ofiram et al. were the only ones to publish results with correction using the external fixator device. In his sample of six patients with hereditary multiple exostosis, two osteotomies were performed. An supramalleolar medial closure osteotomy for acute correction and another of the proximal lateral tibia for gradual correction by open wedge. There were reported four cases of pin-site infection, one case of neuropraxia of the peroneal nerve and one case in which the osteotomised fibula cause local pressure and discomfort on the skin.[36] Al-Saati et al., as well as Puddu et al., cites gradual correction techniques without providing detail on the series of cases or complications seen.[28,29] Van Lieshout et al.[9] reported a series of cases but with a focus on ligamentous laxity and the time to joint arthroplasty, but without a description of the complications of the procedure.

There are limitations in this study. The sample is not large enough for meaningful statistical analysis. Data for comparison were also absent in the literature of patients who had similar treatment. Additionally, the short follow-up of some patients in this sample would have made assessment for late complications incomplete. The last limitation is a loss of data in six patients decreasing the final sample size.

Conclusion

Valgus deformities in the tibia may be corrected acutely or gradually. Treatment selection is based on surgeon expertise and the specifics of the clinical problem and condition of the patient. This series presents the mid-term outcomes of using a monolateral external fixator on the lateral aspect of the leg for gradual correction. The results indicate it to be an efficient treatment with a risk of complications comparable to that in the literature.

Further studies are needed to better assess long-term outcomes and complications.

Author's Contribution

The authors' participation in this technical note using the ICMJE authorship criteria:

Diego Perez da Motta made substantial contributions to the conception and design of the work; participated in the preparation of the work, reviewing it critically for intellectual content; evaluated the final version with approval to be published. This author declares himself responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work have been investigated and resolved in an appropriate manner.

José Leonardo Rocha de Faria made substantial contributions to the conception and design of the work; participated in the preparation of the work, reviewing it critically for intellectual content; evaluated the final version with approval to be published. This author declares himself responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work have been investigated and resolved in an appropriate manner.

Arnaldo Couto made substantial contributions to the conception and design of the work; participated in the preparation of the work, reviewing it critically for intellectual content. This author declares himself responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work have been investigated and resolved in an appropriate manner.

Diego Pinheiro Aguiar made substantial contributions to the conception and design of the work; participated in the preparation of the work, reviewed it critically for intellectual content; evaluated the final version with approval to be published. This author declares himself responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work have been investigated and resolved in an appropriate manner.

Marcus Vinicius Galvão do Amaral made substantial contributions to the conception and design of the work; participated in the preparation of the work, reviewing it critically for intellectual content; evaluated the final version with approval to be published. This author declares himself responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work have been investigated and resolved in an appropriate manner.

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