

# Ankle arthrodesis via a transfibular approach and circular external fixation

## Artrodese de tornozelo por acesso transfibular e fixação externa circular

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### ABSTRACT

**Objective:** To present the radiographic and functional outcomes of a series of 11 cases of ankle arthrodesis performed with a circular external fixator using the Ilizarov method and a transfusion approach, conducted between January 2017 and June 2018.

**Methods:** The patients were evaluated according to American Orthopedic Foot and Ankle Society (AOFAS) and visual analogue scale (VAS) scores. Ankle radiographs were evaluated on anteroposterior and profile views. All patients underwent a similar procedure regarding the surgical approach and assembly of the Ilizarov apparatus.

**Results:** Eleven patients, with a mean age of 44.81 years (28-70 years), underwent surgery. The average follow-up time was 50.81 weeks (13-90 weeks). The main indication for surgery was post-traumatic secondary arthritis. The mean functional AOFAS score was 55.72 (45-64) points. An evaluation of the soft tissues revealed surgical wound healing of the transfibular approach in 9 patients (81%). All cases showed signs of superficial pin- or wire-tract infection. Union was reported in 10 patients (90.9%), and the radiographic varus deformities found in 2 patients did not exceed 7°. No additional surgical procedure was required during follow-up.

**Conclusion:** Ankle arthrodesis performed by a transfibular approach and fixation performed by the Ilizarov method were efficient, promoted the functional restoration of the patient, considering the complexity of the cases, and resulted in a high union rate.

**Level of Evidence IV; Therapeutic Studies; Case Series.**

**Keywords:** Ankle injuries; Arthrodesis; Ilizarov technique.

### RESUMO

**Objetivo:** Apresentar os resultados radiográficos e funcionais de uma série de onze casos de artrodese de tornozelo realizados com fixador externo circular pelo método de Ilizarov e acesso transfibular, operados entre janeiro de 2017 e junho de 2018.

**Métodos:** Os pacientes foram avaliados de acordo com o escore AOFAS (*American Orthopaedic Foot and Ankle Society*) e VAS (*Visual Analogue Scale*). As avaliações radiográficas foram feitas sobre as radiografias de tornozelo nas incidências anteroposterior e perfil. Todos os pacientes foram operados de forma semelhante no acesso cirúrgico e na montagem do aparelho.

**Resultados:** No período foram operados 11 casos, a média de idade foi de 44.81 anos (28-70 anos). O seguimento médio dos pacientes foi de 50.81 semanas (13-90 semanas). A principal indicação encontrada foi a artrose secundária, pós-traumática. Resultados funcionais AOFAS apresentaram uma média de 55.72 (45-64) pontos. A avaliação de partes moles resultou em cicatrização da ferida operatória no acesso cirúrgico transfibular em 9 pacientes (81%). Todos os casos apresentaram no seguimento sinais de infecção superficial em trato do pino ou fio. A consolidação foi relatada em 10 pacientes (90,9%), o desvio radiográfico encontrado em 2 pacientes não excedeu 7° de desvio em varo. Nenhum procedimento cirúrgico adicional foi necessário durante o seguimento.

**Conclusão:** A artrodese de tornozelo por acesso transfibular e a fixação pelo método de Ilizarov mostrou-se eficiente, promovendo a restauração funcional do paciente em relação à complexidade dos casos, com índice elevado de consolidação.

**Nível de Evidência IV; Estudos Terapêuticos; Série de Casos.**

**Descritores:** Traumatismos do tornozelo; Artrodese; Técnica de Ilizarov.

Work performed at the Universidade Federal de São Paulo, São Paulo, SP, Brazil.

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## INTRODUCTION

Tibiotalar or ankle arthrodesis is among the most frequently performed arthrodesis procedures in the extremities<sup>(1)</sup>. Joint fusion is indicated in several situations that share a common outcome of pain and deformity in this region<sup>(2,3)</sup>. The aim of the procedure is to perform ankle arthrodesis with the joint in an adequate position relative to the leg to provide pain relief, correct the deformity and reestablish the function of the lower limb<sup>(1-5)</sup>.

However, despite the good results obtained with this procedure using conventional techniques with internal osteosynthesis, certain situations are effectively better treated with external fixation approaches<sup>(4,6)</sup>. Usually, these are challenging cases in which extensive scar tissue, large angular deformities, bone loss, infections and other complications are present<sup>(1,5-7)</sup>.

External fixation using a circular fixator according to the Ilizarov method can promote solid fusion and correct the associated bone deformity. Of note, this method also has the ability to complement angular corrections by increasing axial compression at subsequent visits during outpatient follow-up<sup>(3,8)</sup>.

We found encouraging results in the literature regarding the union of ankle arthrodesis using the Ilizarov method. The union rate in studies of external fixation performed by this method ranges from 77% to 100%<sup>(9-12)</sup>, and a significant improvement is observed in the functional outcomes of operated patients<sup>(3,7,9,11-13)</sup>. The complications associated with the method mainly include pin tract infection, loss of alignment and non-union. However, the complication rates did not exceed a mean of 30% of treated patients<sup>(6,7,14,15)</sup>.

The objective of the present study is to present the radiographic and functional outcomes of a series of ankle arthrodesis cases performed using a circular external fixator with the Ilizarov method and a transfibular approach.

## METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 01514918.5.0000.5505.

This is a retrospective, observational, descriptive, case series study without a control group.

This case series includes patients who underwent ankle arthrodesis with a circular external fixator by the Ilizarov method between January 2017 and June 2018. The surgery was proposed only after failure of previous surgical treatment of fractures by osteosynthesis in 10 patients and revision ankle arthrodesis with conventional closed surgery in one patient, with an initial follow-up period of at least 9 months. During the study period, no arthrodesis procedures with an external fixator were performed for primary ankle osteoarthritis. The patients were evaluated according to American Orthopedic Foot and Ankle Society (AOFAS)<sup>(16)</sup> and visual analogue scale (VAS)<sup>(17)</sup> scores at the last outpatient visit during the study period after removal of the external fixator. Radiographic measurements were made on anteroposterior and profile views of ankle radiographs that were requested during patient follow-up. Radiographic union was defined as bridging bone across at least 3 cortices. Additional information was collected in the electronic medical records of our institution, which ranged from January 2017 to June 2018, to obtain data on the injury site, cause of injury, demographic factors and complications during the use of the Ilizarov apparatus.

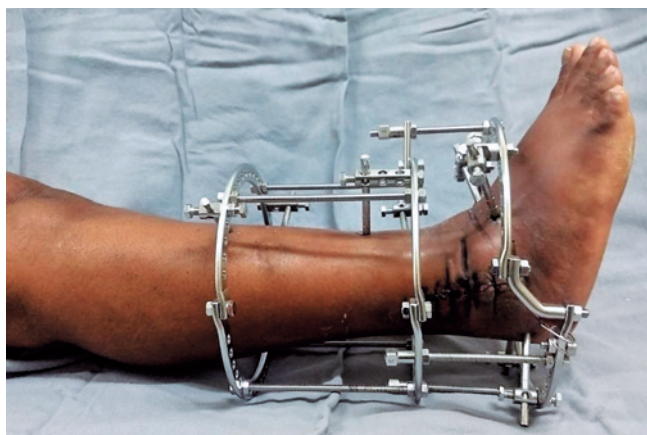
## Surgical technique

All surgical interventions were performed using a lateral approach over the fibula, lateral malleolus osteotomy, syndesmosis debridement and chondral cartilage denudation using osteotomes and curettes. The medial approach was then performed over the distal tibia with medial malleolus osteotomy. Then, reduction was performed with bone apposition, aiming to achieve the greatest possible contact between the tibiotalar surface and adequate positioning of the foot (plantigrade), which was fixed with two 3.0 Kirschner wires and confirmed intraoperatively by radioscopy on anteroposterior and profile views. After stabilization, the lateral and medial approach were closed in planes, and the Ilizarov apparatus was assembled and installed (Figure 1 and 2). The apparatus included a block with 2 rings in the distal tibia fixed with four elements, including two 6.0-mm Schanz pins in the proximal ring and two pins in the distal ring, which were positioned in an orthogonal arrangement at the most anterior and medial parts of the tibia. The apparatus also included one semi-ring in the posterior region of the hindfoot, which was fixed to the calcaneus with

two orthogonal and posterior 6.0 mm Schanz pins and a 1.8 mm transverse smooth wire that was tensioned with 50 kgf and connected to an anterior semi-ring. This was



**Figure 1.** Ilizarov circular external fixator, anteroposterior.  
**Source:** author's personal archive



**Figure 2.** Ilizarov circular external fixator, showing the pins directed at the talus.  
**Source:** Author's personal archive.

attached to the talus in an orthogonal position with two 6.0-mm Schanz pins, which were inserted on the anteromedial and anterolateral surfaces of the talus (Figure 2). All pins were repositioned after low-speed drilling in the cortices, followed by manual insertion. Lastly, local dressings were applied. The postoperative protocol consisted of gradual weight bearing according to patient tolerance, dressing, radiographic control during the first week and removal of the stitches in the second week. Monthly follow-up was performed until radiographic union (Figure 3 and 4) and absence of pain in the hindfoot were achieved. Monthly, we routinely applied 1 mm of additional compression at the arthrodesis site via the apparatus. After radiographic union, the removal protocol consisted of release of the Ilizarov rods and a valgus, varus, antecurvatum and recurvatum stress test with full weight bearing. In the absence of pain and mobility at the arthrodesis site, the apparatus was left in place, regardless the degree of looseness, with the rods connecting the rings. The apparatus was then removed the following week.



**Figure 3.** Anteroposterior radiograph of the ankle after union.  
**Source:** Author's personal archive



**Figure 4.** Profile radiograph of the ankle after union.

**Source:** Author's personal archive.

## RESULTS

During the study period, 11 patients were treated using circular external fixation and a transfibular approach. Nine patients were male, and 2 were female. The mean age was 44.81 years (28-70 years), with 6 cases of surgery on the right ankle and 5 on the left ankle (Table 1). The average follow-up period was 50.81 weeks (13-90 weeks). The main indication for surgery was post-traumatic secondary arthritis, mainly due to bimalleolar or trimalleolar fracture in 6 patients, pilon fracture in 4 patients, and one case of non-union of tibio talo calcaneal arthrodesis by an intramedullary nail, with an initial diagnosis of pilon fracture. The presence of bone infection or osteosynthesis material due to a previous surgery was observed in 5 patients in the preoperative diagnosis (Table 1).

The mean functional AOFAS score was 55.72 points (Table 2). An evaluation of soft tissues revealed surgical wound healing of the transfibular approach in 9 patients (81%), with 2 patients (19%) showing signs of superficial infection with purulent surgical wound discharge. These

patients were treated with oral antibiotics for 14 days and showed subsequent improvement of the local infection. During follow-up, all 11 patients showed signs of superficial infection in the pin or wire tract (1 or more elements) and were treated with oral antibiotics for 14 days, resulting in total improvement of the symptoms without removal of the element. There was no report of signs of deep tissue infection. No additional surgical procedure was required during follow-up. Radiographic union was reported in 10 patients (90.9%). Radiographic deformity of the varus was present in 2 patients (Table 3) and did not exceed 7°; both patients were asymptomatic during treatment and after removal of the external fixator. In the follow-up radiographs (Table 3), signs of subtalar joint degeneration (decreased joint space, subchondral bone sclerosis and formation of subchondral cysts) were observed in 5 patients (50%, case 2 was excluded from this evaluation because that patient had already undergone arthrodesis of the joint).

## DISCUSSION

Conventional ankle arthrodesis can be performed using various methods, including screws, plates, rods or combined with various osteosynthesis methods. However, the presence of unfavorable local conditions, such as bone loss, infection and breakage of the previously used material, can lead to a difficult clinical situations<sup>(4,5)</sup>.

The external fixation technique provides a series of advantages over the other forms of ankle arthrodesis, including rigid immobilization and significant resistance against shear forces, flexion and torsional stress. The Ilizarov apparatus is a versatile external fixator that, in addition to its stable construction, allows the application of a primary (static) compressive force and a continuous (dynamic) compressive force along the axis of the limb<sup>(6,7)</sup>. The distance between the apparatus and the skin allows better observation of surgical wound healing, especially if tissue grafts are used for local coverage. In addition, it offers the capacity for controlled and progressive dynamization, which may be used to stimulate union during treatment<sup>(3,15)</sup>.

Using the external fixation method, the union rates showed favorable results, as demonstrated by Fragomen et al., resulting in an 84% union rate in 91 cases<sup>(12)</sup>. The same authors reported a mean AOFAS score of 71 points in 49 patients in their case series. A case series with a smaller sample, as reported by Easley et al. (22 patients), of revision arthrodesis with an external fixator, presented a union rate of 84.6% and a modified AOFAS score of 65.9 points<sup>(18)</sup>.



**Table 1.** Demographic data, initial diagnosis, follow-up time and functional outcomes

Patient	Age	Sex	Side	Diagnosis	Follow-up time (weeks)	VAS	AOFAS
1	28	M	L	Open bimalleolar fracture Post-traumatic arthritis Infection after osteosynthesis	41	5	54
2	39	M	L	Failure of TTC arthrodesis by intramedullary nail	26	4	58
3	58	M	R	Pilon fracture Post-traumatic arthritis	37	2	64
4	43	M	L	Pilon fracture Post-traumatic arthritis	58	1	52
5	42	M	L	Bimalleolar fracture Post-traumatic arthritis Infection after osteosynthesis	72	4	61
6	54	F	R	Pilon fracture Post-traumatic arthritis	76	5	62
7	48	M	R	Post-traumatic arthritis Failure of osteosynthesis material Osteomyelitis	81	5	49
8	70	M	L	Post-traumatic arthritis Osteomyelitis	90	2	62
9	41	M	R	Trimalleolar fracture Post-traumatic arthritis	13	7	52
10	27	M	R	Pilon fracture Post-traumatic arthritis	17	2	54
11	43	F	R	Trimalleolar fracture Post-traumatic arthritis Osteomyelitis	48	6	45
<b>Mean</b>	<b>44.81</b>				<b>50.81</b>	<b>3.90</b>	<b>55.72</b>

VAS - visual analogue scale; AOFAS - American Orthopedic Foot and Ankle Society, Ankle-Hindfoot Scale; TTC - tibiototalcanal.

Source: prepared by the author based on the results of the research.

**Table 2.** Ankle and hindfoot AOFAS score

Patient	1	2	3	4	5	6	7	8	9	10	11	Total
Pain	30	20	30	30	20	30	20	30	20	30	20	<b>25.45</b>
Functional	7	7	7	7	7	7	7	7	7	0	0	<b>5.72</b>
Maximum walking distance	4	2	2	0	5	0	2	2	0	2	0	<b>1.72</b>
Walking surface	3	3	3	3	3	3	3	3	3	0	3	<b>2.72</b>
Gait abnormality	4	8	4	4	8	4	4	4	4	4	4	<b>4.72</b>
Ankle and hindfoot stability	8	8	8	8	8	8	8	8	8	8	8	<b>8</b>
Alignment	5	10	10	0	10	10	5	10	10	10	10	<b>8.18</b>
<b>Total AOFAS (maximum 86)</b>	<b>54</b>	<b>58</b>	<b>64</b>	<b>52</b>	<b>61</b>	<b>62</b>	<b>49</b>	<b>62</b>	<b>52</b>	<b>54</b>	<b>45</b>	<b>55.72</b>

Source: prepared by the author based on the study results.

**Table 3.** Evaluation of the transfibular surgical approach and radiographic evaluation

Case	Soft tissues: surgical approach	Radiographic union	Radiographic angular deformity	Signs of arthritis and subtalar joint
1	Healed	Yes	No	No
2	Healed	Yes	No	Previous arthrodesis
3	Healed	Yes	No	Yes
4	Healed	Yes	No	Yes
5	Healed	Yes	No	Yes
6	Signs of superficial infection, without pus	Yes	Yes (5° varus)	No
7	Healed	Yes	Yes (7° varus)	Yes
8	Healed	Yes	No	Yes
9	Signs of superficial infection, without pus	Yes	No	No
10	Healed	No (union in 1 cortex)	No	No
11	Healed	Yes	No	No

Source: prepared by the author based on the study results.

Additionally, Eylon et al. analyzed 17 patients and observed a AOFAS score of 65 points and union in all cases<sup>(3)</sup>.

The AOFAS score takes into account the mobility in the hindfoot, which cannot be assessed once tibiotarsal arthrodesis is performed. As the mobility of the ankle is eliminated, the 14 points assigned for evaluating the mobility in this region are lost, resulting in a maximum score of 86 points<sup>(3)</sup>. Arthrodesis with either internal fixation or external fixation results in a mean AOFAS score ranging from 60 to 80 points<sup>(3,9)</sup>. The results in the literature, as in the present study, suggest that the use of external fixation does not disrupt the usual functional outcome of arthrodesis, taking into account the additional complexity of cases treated with external fixation.

There are disadvantages in the use of external fixators, including pin tract infection, pin breakage, fractures, joint stiffness and limitations in daily life, in addition to psychological problems associated with their use<sup>(5,19)</sup>. The complications in our study are consistent with those reported by other authors and are similar to those reported by Rochman et al. in their study of 11 patients undergoing tibioalcaneal or tibiotarsal arthrodesis. In a study by Rochman et al., 9 patients achieved complete union, 1 patient had stable pseudarthrosis, and 1 patient achieved union after revision surgery. All cases were treated after necrosis of the talus due to trauma (4 patients) or the presence of osteomyelitis or infected pseudarthrosis (7 patients)<sup>(14)</sup>. Assessment of the postoperative outcomes showed a mean AOFAS score of 65 points (44 to 77 points). Superficial infection was observed in the pin tract in all 11 patients, who were treated with oral antibiotics, with no presence of deep infections during follow-up, which suggests elimination of the preoperative infection<sup>(14)</sup>. The same author reported the following major complications in 6 patients: varus deformity greater than 5° in 1 patient, an allergic reaction to the antibiotic in 1 patient and complications with the proximal regenerate in the focus of stretching in the other 4 patients<sup>(14)</sup>. In our study, 2 cases of varus deformity of the hindfoot were observed, which were asymptomatic at the end of follow-up. The presence of superficial infection was observed in all patients.

Eylon et al. observed minor complications without the need for surgical intervention, such as bruises, superficial infections and pin breakage, in all patients in their case series. However, the authors did not report the diameter of the fixation elements used<sup>(3)</sup>. We did not observe any breakage of the apparatus during the follow-up period in our study.

The functional limitations imposed by the apparatus can be confused with the limitations resulting from ankle arthrodesis. In our case series, most patients (81%) reported a maximum walking distance of 3 blocks. All patients reported difficulty walking on irregular surfaces and slopes. Our findings differ from those of a series by Rochman et al. reported at the end of follow-up (mean 35 months, ranging from 10 to 81 months), in which 7 of the 11 patients reported no limitations in their daily activities and were able to walk for more than 6 blocks. Two of the 11 patients were able to walk between 4 and 6 blocks, and the remaining two patients reported not being able to walk for more than one block<sup>(14)</sup>. Few studies in the literature have evaluated the VAS, which quantifies the pain currently experienced by the patient. In the present study, the mean of 3.90 points suggests the presence of mild to moderate pain associated with the use of the external fixator and may be associated with a worsening of the functional scores (AOFAS).

Several surgical approaches to the ankle can be considered for tibiotarsal arthrodesis. The choice is influenced to the type of deformity, fixation technique, soft tissue condition and surgeon experience<sup>(2)</sup>. The lateral or transfibular approach is a common approach that has historically been used in the treatment of this joint disease<sup>(20)</sup>. In addition to the need for an osteotomy, it is common for debridement on the opposite side of the joint to be performed via a complementary approach over the medial malleolus<sup>(1,21)</sup>. As in the present study, few complications are reported for this method and are usually limited to superficial infections and wound dehiscence is treated with dressings and antibiotics. In the study by Colman et al., including 48 patients who underwent a transfibular approach and internal fixation, development of superficial infections and dehiscence were observed in only 3 patients<sup>(22)</sup>. Akra et al., in their series of 26 cases of ankle arthrodesis using a transfibular approach with internal fixation, reported the presence of complications in 3 cases, including 2 cases with superficial infection and 1 case of reflex sympathetic dystrophy. All cases were resolved with drug treatment<sup>(20)</sup>.

Signs of degeneration of the subtalar joint were present in almost half of the patients in this series of 5 patients (except in the case of previous tibiotarsal arthrodesis). The presence of radiographic signs of degeneration in adjacent joints, such as the subtalar joint, may be due to the initial injury, as well as to joint overload after ankle arthrodesis<sup>(23)</sup>. However, from the biomechanical point of view, there is no consensus on the extent to which arthrodesis

may contribute to the progression of adjacent joint degeneration<sup>(23,24)</sup>. We chose to apply the fixator to the talus and calcaneus while periodically compressing the tibiotalar arthrodesis and stabilizing the subtalar joint.

The present study has some limitations. Because it is a case series, only a small number of patients, all with traumatic etiology, were evaluated in a reference center. However, we observed the progression to union in the majority of

cases, as well as the absence of major complications requiring subsequent surgical interventions.

## CONCLUSION

Ankle arthrodesis via a transfibular approach and fixation by the Ilizarov method was efficient, with good functional outcomes when taking into account the complexity of the cases, and showed a high union rate and few complications.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: VFP \*(<https://orcid.org/0000-0002-1005-6089>) conceived and planned the activities that led to the study, wrote the article, interpreted the results of the study, approved the final version; VYM \*(<https://orcid.org/0000-0002-4676-2954>) conceived and planned the activities that led to the study, wrote the article, interpreted the results of the study, approved the final version; HB \*(<https://orcid.org/0000-0001-9207-7707>) wrote the article, participated in the review process, approved the final version; HCPJ \*(<https://orcid.org/0000-0001-8332-0365>) wrote the article, participated in the review process, approved the final version; JCFFJ \*(<https://orcid.org/0000-0002-5687-8774>) wrote the article, participated in the review process, approved the final version; NSBM \*(<https://orcid.org/0000-0003-1067-727X>) participated in the review process, approved the final version. \*ORCID (Open Researcher and Contributor ID).

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