Use of the Ilizarov method for the treatment of post-traumatic deformities and discrepancies of the tibia: Case series

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ABSTRACT
Introduction: Post-traumatic sequelae of the tibia are a common problem faced by orthopedists every day. The Ilizarov method, through careful planning, has achieved great results. **Objective:** To assess the outcome of the treatment of post-traumatic deformities and discrepancies of the tibia treated with the Ilizarov circular fixator. **Methods:** Thirteen patients were evaluated by clinical and radiological criteria during a minimum follow-up of 24 months. The results were good and excellent in all cases, and bone consolidation was achieved in all patients. **Conclusion:** The Ilizarov method is useful and versatile to solve any type of post-traumatic sequelae of the tibia, without the need for grafts or bone substitutes.
Key words: Tibia; Ilizarov; deformity; post-traumatic.
Level of Evidence: IV

Utilización del método Ilizarov para el tratamiento de desejes y discrepancias postraumáticos de la tibia. Serie de casos

RESUMEN
Introducción: Las secuelas postraumáticas de la tibia representan un problema común al que nos enfrentamos los ortopedistas día a día. El método Ilizarov, mediante una planificación minuciosa, ha dado grandes resultados. **Objetivo:** Valorar el resultado del tratamiento de desejes y discrepancias postraumáticas de la tibia mediante el fijador circular de tipo Ilizarov. **Materiales y Métodos:** Se evaluó a 13 pacientes mediante criterios clínicos y radiográficos durante un seguimiento mínimo de 24 meses. Los resultados fueron buenos y excelentes, y se logró la consolidación ósea en todos los pacientes. **Conclusión:** El método Ilizarov es útil y versátil para resolver cualquier tipo de secuela postraumática de la tibia, sin necesidad de injertos o sustitutos óseos.
Palabras clave: Tibia; Ilizarov; deformidad; postraumático.
Nivel de Evidencia: IV

INTRODUCTION

The Ilizarov method, created by Gavriil Abramovich Ilizarov in Kurgan (former USSR), is based on the biological principles of bone development to perform distraction osteogenesis.[1] The mechanism consists in subjecting living tissue to stress by gradual traction, making it metabolically active. As a result, it undergoes a process of regeneration and growth.

The Ilizarov method uses a multiplanar circular external fixator, a versatile tool in the treatment of deformities, discrepancies and even bone loss. Currently, there are few publications on this treatment, its approach and the results in post-traumatic sequelae of the tibia.[2,3]

In Argentina, there are no specific statistical data available, but hospital experience indicates that the lower limb is the most affected anatomical segment during motor vehicle accidents. The difficulties that arise when treating this type of conditions are usually the scarcity of resources to administer appropriate treatment, and the socioeconomic status and self-care of the patient, which are conditioning factors that must be considered when determining a procedure.

Received on February 15, 2018. Accepted after evaluation on July 6, 2018 • MAURO R. VIVAS, MD • vivasmauro@hotmail.com
How to cite this paper: Vivas MR, Cordano OR. Use of the Ilizarov method for the treatment of post-traumatic deformities and discrepancies of the tibia. Case series. *Rev Asoc Argent Ortop Traumatol* 2019;84(2):136-142. http://dx.doi.org/10.15417/issn.1852-7434.2019.84.2.827

Careful case planning and assembly of the circular fixator before the surgery allow the management of sequelae and avoidance of complications that may occur during the treatment established. The approach allows to correct deformities affecting various planes and discrepancies in a biological way without resorting to bone grafting, a resource that is difficult to access for some Orthopedic and Traumatology Departments.

The objective of this study was to analyze the outcome of a series of patients with post-traumatic tibia sequelae treated with the Ilizarov method.

MATERIALS AND METHODS

A retrospective study was conducted on 13 patients with nonunion, discrepancies or deformities secondary to post-traumatic tibia sequelae treated with the circular Ilizarov external fixator in our institution from March 2012 to March 2015.

The inclusion criteria were as follows: tibia injury sparing the joint segment, patients over 18 years old or with a closed growth plate, and a minimum follow-up of 24 months after removal of the circular external fixator. Patients were not excluded due to treatment failure.

Of the 13 patients studied, six had open fractures and seven had closed fractures as primary lesion. Three were initially treated at our institution and 10 were referred from the bone reconstruction clinic on an outpatient basis.

Table 1 shows previous treatments, and Table 2 shows the sequelae treated with the described method.

Table 1. Previous treatment of patients treated with the Ilizarov method in our study

Treatment	Number
Intramedullary rod	3
Osteosynthesis	4
External fixator	2
Cast	4
Total	**13**

Table 2. Types of sequelae treated with the Ilizarov method

Sequelae	Number
Aseptic nonunion	6
Stiff nonunion	2
Infected nonunion	3
Poor consolidation and presence of discrepancies	2
Total	**13**

In patients without fracture consolidation, we used the nonunion classification proposed by Paley *et al.* as a reference to determine the surgical approach (Table 3).

Table 3. Classification of nonunions by Paley *et al.*

>1 cm bone loss	<1 cm bone loss
B1 Bony defect	A1 Stiff nonunion
B2 Shortening	A2 Mobile nonunion
B3 Bony defect and shortening	

Surgical planning was based on X-rays taken at 2.05 m to obtain a size closer to the real one. The contralateral leg was taken as a normal parameter in 11 cases (without previous conditions) and the anatomical axes according to Paley's nomogram were used in the rest of the patients.[4]

The basic apparatus consists in two modules formed with two rings joined by hinges and a motor, as needed, at the center of rotation of the angulation (CORA) (Figure 1).

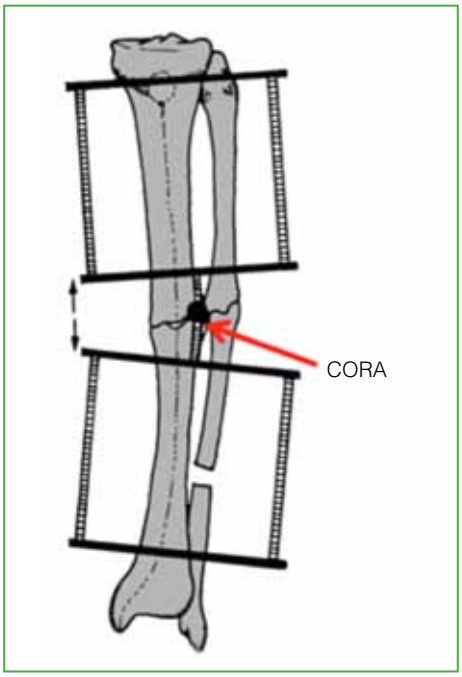

Figure 1. Center of rotation of the angulation.

Preparation was carried out as needed for correction or lengthening on each patient (diameter of rings, placement of rods and length of the assembly). In all cases, we opened the fracture site, debrided the fibrous tissue and resected the bony margins. The decision to make progressive opening wedge—or lengthening—corrections was based on recovering the bone loss produced by the initial sequelae and debridements performed with a minimum discrepancy of 3 cm compared with the contralateral limb (Figure 2).[5-7]

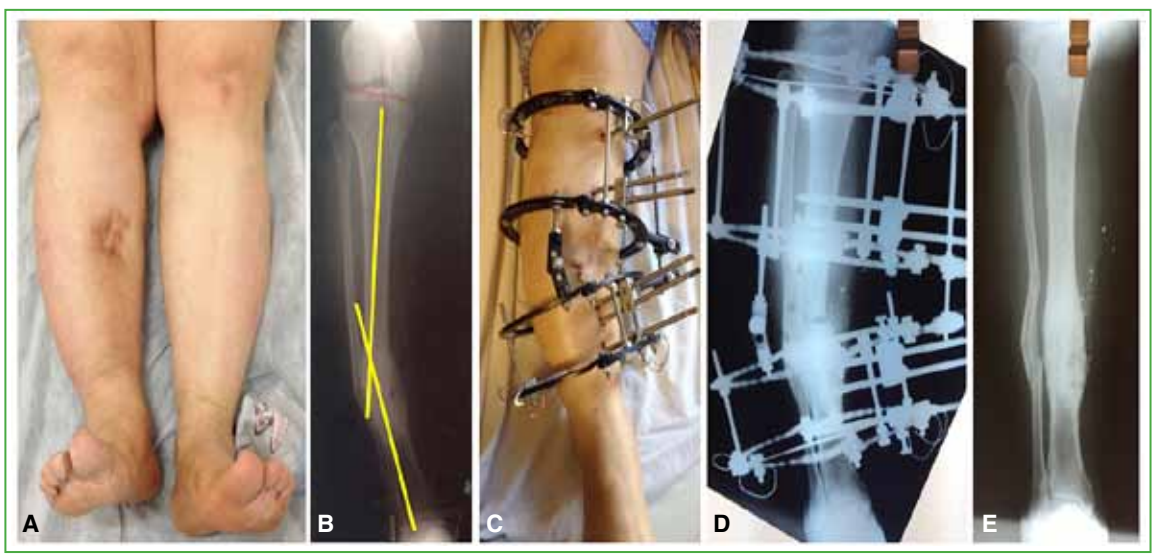

Figure 2. 45-year-old woman with sequelae of an untreated tibia fracture and varus consolidation of the fracture. An osteotomy was performed at the center of rotation of the angulation for dynamic correction and lengthening. **A and B.** Preoperative scans. **C and D.** Beginning of treatment. **E.** Result after 6 months.

Correction began between the seventh and tenth day after surgery, and the rate was 1 mm/day, divided into a quarter of a motor revolution, every six hours. The average time was 42 days (range 26-48) (Figure 3).

In patients with previous discrepancy (two cases), the assembly was prepared for bone lengthening; in case of shortening >2 cm secondary to the correction (one patient), we decided to modify the assembly in the office, without performing a new surgical procedure, and to continue bone with the lengthening until achieving the desired length.

Figure 3. A and B. 30-year-old man with stiff nonunion in the antecurvatum of the tibia. **C-E**. Cleaning of the fracture site and assembly of the apparatus; progressive correction and compression were carried out. **F-I.** Final result after 5 months of treatment.

The functional and radiological results were evaluated according to the ASAMI classification system (Table 4).

Table 4. Evaluation of functional and radiological results according to the ASAMI classification system

Bone results	
Excellent	Union, no infection, deformity <7°, limb length discrepancy (LLD) <2.5 cm
Good	Union plus any two of the following: absence of infection, deformity <7°, LLD <2.5 cm.
Fair	Union plus any one of the following: absence of infection, deformity <7°, LLD <2.5 cm.
Poor	Nonunion/refracture/union plus infection plus deformity >7° plus LLD >2.5 cm
Functional results	
Excellent	Active, no limp, minimum stiffness (loss of <15° knee extension/<15° ankle dorsiflexion), no reflex sympathetic dystrophy (RSD), insignificant pain
Good	Active, with one or two of the following: limp, stiffness, RSD, significant pain
Fair	Active, with three or all of the following: limp, stiffness, RSD, significant pain
Poor	Inactive (unemployment or inability to return to daily activities because of injury)
Failure	Amputation

Through a telephone survey of patients undergoing treatment, it was established that cosmetic results were also satisfactory.

RESULTS

The results obtained were evaluated according to the Paley criteria: six patients had good results and six had excellent results; for reasons external to the treatment, one of the patients was lost to follow-up, so no further details could be obtained (Case 4).

In all patients, consolidation of the osteotomy site or nonunion was achieved without infection; one presented a length discrepancy measuring >2.5 cm (3.1 cm) and five patients had a deformity of >7° (Table 5).

Table 5. Result evaluation using the Paley score

Patient	Consol. w/o infection	Residual deformity	Discrepancy	Result	Weakness	Equinus	Dystrophy	Pain	Work inactivity	Result
1	Yes	> 7 mm	< 2.5	Good	No	No	Sí	No	Yes	Good
2	Yes	> 7 mm	< 2.5	Good	No	No	Sí	No	Yes	Good
3	Yes	> 7 mm	< 2.5	Good	No	No	No	No	No	Excellent
4										
5	Yes	< 7 mm	> 2.5	Good	No	No	No	No	No	Excellent
6	Yes	< 7 mm	< 2.5	Excellent	No	No	No	No	No	Excellent
7	Yes	> 7 mm	< 2.5	Good	No	No	No	No	No	Good
8	Yes	< 7 mm	< 2.5	Excellent	No	No	No	No	No	Excellent
9	Yes	> 7 mm	< 2.5	Good	No	No	No	No	Yes	Excellent
10	Yes	< 7 mm	< 2.5	Excellent	No	No	No	Yes	Yes	Good
11	Yes	< 7 mm	< 2.5	Excellent	No	No	No	No	No	Excellent
12	Yes	< 7 mm	< 2.5	Excellent	No	No	Yes	Yes	No	Good
13	Yes	> 7 mm	< 2.5	Good	No	No	No	Yes	Yes	Good

Dahl[8] classified the difficulties inherent to the treatment as a problem, obstacle and complication, according to the possibility and the type of treatment it requires. A *problem* is an event that does not require surgical treatment; an *obstacle* is a difficulty that requires surgery or temporary suspension of treatment; and a *complication* is one that was resolved during treatment (Table 6). Seven patients presented infection around the holes (treated with oral antibiotics) and two had skin necrosis in the area of the corrective osteotomy—one of them required a gastrocnemius muscle flap.

DISCUSSION

In their series of 15 cases, Krappinger *et al.*[9] achieved results similar to ours. The treatment not only requires a medical process, but also the commitment of the patients and their closest loved ones during progressive correction of the deformity. On the other hand, Bernstein *et al.*[10] compared the results of the treatment with a circular fixator and a circular fixator plus internal osteosynthesis, and found no significant differences in the final result, although they did report an improvement in patient comfort after the fixator was removed months before consolidation.

In his series of cases, Chadhha reported a higher rate of complications and agrees with Cirpar, who reported a dramatic increase in the rate of complications when exceeding the limb lengthening length by 20-25% in a single stage.[11,12]

Table 6. Classification of difficulties and complications during treatment and their implications in the final result

Classification of postoperative difficulties by Dr. Dahl				
Problems (non-surgical resolution)	**Obstacles** (surgical resolution during the course of treatment)	**Minor complications** (That are solved without surgery after the end of treatment)	**Mayor or true complications** (Requiring surgery after the end of treatment)	
			They do not affect final result of treatment	They do affect final result of treatment
Muscle contracture	Muscle contracture	Muscle contracture	Muscle contracture	
Subluxation of a joint	Subluxation of a joint	Subluxation of a joint	Subluxation of a joint	
Mild axial misalignment (<5°)	Severe axial misalignment (>5°)			
Neurological damage	Neurological damage		Neurological damage	
			Compartment syndrome	
Lower limb edema				
Excessive soft tissue tension				
			Deep vein thrombosis	
Premature consolidation	Premature consolidation			Premature consolidation
Late consolidation	Late consolidation		Late consolidation	
Superficial infection surrounding the rod	Superficial infection surrounding the rod		Bone infection throughout the rod path	
		Refracture, loss <1 cm lengthening and/or <5° angulation	Refracture, loss >1 cm lengthening and/or >5° angulation	
		Joint stiffness	Joint stiffness	
Pain	Pain			
Depression				

The treatment of the sequelae of the tibia with discrepancies or deformities requires a team specialized in its management. Bone quality and soft-tissue condition are essential for treatment success; the surgical procedure is important, but so is the postoperative period that requires follow-up and prevention of any complications that may arise.[13-15]

CONCLUSIONS

The Ilizarov method is an excellent approach for the rescue treatment of post-traumatic sequelae of the tibia. Careful planning and patient commitment are determining factors of the results achieved.

As weaknesses of our work, we can mention two: 1) although final radiological and functional results were good and excellent, the lack of a preoperative classification hinders the objectivity of the study to analyze the patient before and after surgery; and 2) although there were no callus fractures, the follow-up has been short to medium term (24 months) and, therefore, the assessment of the mechanical strength of the new bone during high-impact activities is difficult to carry out.

Currently, there are several methods and approaches to treat the type of sequelae dealt with on this paper; however, it has been shown that the Ilizarov method achieves predictable results as the rescue treatment of various deformities and discrepancies, specially of the long bones of the lower limbs, where others have failed. What makes this method even more appealing is the possibility of managing any type of sequelae without limitations due to bone defects; without the need for autografting or allografting; and without poor-quality soft tissue or active infections; as well as solving any type of complication with the same apparatus.

Conflict of interests: Authors claim they do not have any conflict of interests.

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