

The effects of an early intrahospital rehabilitation on weight bearing during lower extremity lengthening with Ilizarov method

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Purpose: Exerting axial pressure on the affected lower limb remains one of the most crucial elements of Ilizarov method. The objective was to determine the effects of an early intrahospital rehabilitation on weight bearing during lower extremity lengthening with Ilizarov method. *Methods:* The study included 15 patients who underwent lower limb lengthening. The patients were tested on the third day after surgery using the pedobarographic platform. The tests were performed four times in the standing position: twice with the support of forearm crutches and twice without crutches. Patients were asked to either remain in the relaxed standing position (two tests) or use the lower limb equipped with Ilizarov apparatus to support the body weight (two tests). *Results:* In relaxed stance average pressure with forearm crutches was 24.1% for affected limb, as compared to 75.9% for the healthy limb. In test without forearm crutches average pressure for affected limb was 26.1%, as compared to 73.9% for the healthy limb. Patients shifted body weight to the affected limb with forearm crutches on average, at the rate of 53.6%. In test without forearm crutches the affected limb was supporting the body weight at the rate of 48.26%. None of the patients was able to fully support the body weight on the affected leg. *Conclusions:* In spite of strict physiotherapy regimen, patients are neither able to equally distribute their body weight between the two lower limbs nor to shift their body weight to the limb equipped with Ilizarov apparatus.

Key words: pedobarographic, posture, body weight distribution, Ilizarov, physical therapy

1. Introduction

The method of distraction osteogenesis, established by Ilizarov, is a procedure broadly used for lengthening upper and lower limbs [7], [11], [13], [14]. Ilizarov apparatus is characterized by high rigidity and resistance to twisting and bending [11], [14]. Such characteristics allows for very early initiation of intensive physiotherapy program after the surgery, usually starting within the first 24 hours [6]. Such prompt and intensive rehabilitation contributes to quicker recovery, successful learning to walk with Ilizarov ap-

paratus as well as learning to support the body weight on the affected limb [2], [3], [9]. Hospital-based rehabilitation should also include anti-blood clotting, anti-pain and anti-edema prophylaxis, as well as instruction in personal hygiene and self-sufficiency for the period of wearing the apparatus. Properly designed and executed rehabilitation, not only during the hospital stay, but also after the discharge, provides optimal conditions for the new bone formation at the site of osteotomy [3], [6], [9]. Exerting axial pressure on the affected lower limb remains one of the most crucial elements of Ilizarov method [7], [11], [13], [14]. The structure of Ilizarov apparatus allows for micro-

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movements within the longitudinal axis of the limb, which in turn stimulate the process of osteogenesis and improve the blood flow into the affected tissue area. Walking with axial pressure on the lower limb with Ilizarov fixator is very important, because it stimulates the process of the new bone formation and reduces the period of treatment [6], [14]. Properly designed and executed rehabilitation allows for walking with weight bearing on the affected limb which reduces treatment time. Reduction in treatment time reduced complication risk and improved treatment outcomes [6], [13].

The aim of this study was to investigate the effects of an early intrahospital rehabilitation initiated within the first three days post-surgery with respect to the weight bearing potential of the lower limb equipped with Ilizarov apparatus. We analyzed two aspects of weight bearing: prospects for equal body weight distribution between both lower limbs as well as the degree to which the patients were able to shift the body weight to the affected limb.

2. Materials and methods

It was a retrospective study. In total, 72 patients were treated the first time with Ilizarov method at our clinic between 11.2008 till 04.2010. The criteria for inclusion in the study were as follows: patients treated for the first time with Ilizarov method; participation in intensive rehabilitation program; congenital or Perthes disease etiology of shortening, distraction corticotomy with the Ilizarov method within the distal epiphysis of the femur or proximal tibia; patient's consent for the study; presence of baseline values of deformation and shortening in medical records; presence of pedobarographic data; age below 30; lack of mental disorders. Exclusion criteria consisted of: lack of patient's consent for the study; absence in intensive rehabilitation program; axis correction corticotomy; age over 30; lack of pedobarographic data; lack of baseline values of deformation and shortening in medical records. After applying the exclusion criteria, 15 patients (average age was 16 years) were enrolled into the study (Table 1).

All patients underwent intensive rehabilitation regimen that started within the first 24 hours post-surgery to prevent any surgery-related complications as well as complications associated with the apparatus itself (Table 2). During hospitalization all patients obtained analgesics and VAS pain scale, which prior to the tests was 0 in all patients. All patients were

familiarized with the intricacies of the Ilizarov method as well as received instruction on external fixator hygiene. Moreover, all the test patients were equipped with the same type of corrective footwear to reach equal length of lower limb. Research was approved by the Bioethics Committee.

Table 1. Characteristics of research group

Indications for treatment with Ilizarov method	Number of patients	Segment		Age in years (mean \pm SD)	Amount of lengthening [cm] (mean \pm SD)
		thigh	calf		
Congenital limb abbreviation	12	9	3	16 (\pm 5.7)	5 (\pm 2.6)
Perthes disease	3	3		16.3 (\pm 2.3)	3 (\pm 0.5)

Abbreviation: SD – standard deviation.

Table 2. Physiotherapy after the operation with the Ilizarov method

Day 1	Day 2	Day 3	Day 4
Anti-blood clotting exercises	Anti-blood clotting exercises	Postural positions	Excerpt from hospital
Postural positions	Postural positions	Patellae mobilization	
Passive range of motion exercises	Patellae mobilization	Isometric exercises	
	Isometric exercises	Passive and active range-of-motion exercises	
	Passive and active range-of-motion exercises	Standing at the bedside	
	Standing at the bedside	Gait with bilateral weight bearing	
	Gait with unilateral weight bearing	Gait exercises on the stairs	

The tests described in this study were performed three days after the surgical procedure of implanting the Ilizarov external fixator, in the Biomechanics Laboratory in our clinic. Assessment of the load distribution on the operated and healthy limbs was performed on the pedobarographic platform manufactured by Zebris Medical GmbH (Fig. 1). The platform measures 470 \times 320 mm and possesses 1504 sensors. USB connected the platform and PC on which Foot-Print software (version 1.2.4.9) was installed. Com-

puter software allowed for static posture parameters to be processed and archived, which were then subjected to statistical analysis. Every attempt was made with open eyes. Before each measurement, the device was calibrated and each subject was instructed on the specific test method. The patient had both feet on the platform for 60 seconds. For each patient, the study was repeated three times, and then the average score was calculated for further analysis. Prior to the tests, patients underwent a physiotherapy session and obtained a detailed explanation of the protocol.



Fig. 1. Patient during the test on the dynamometric platform

All patients rehearsed accessing the platform prior to the proper test measurements:

- Measurement of weight bearing at the relaxed stance while patients used crutches.
- Measurement of weight bearing at the maximal body weight shifted to the limb equipped with Ilizarov fixator while patients used crutches.
- Measurement of weight bearing at the relaxed stance without the use of crutches.
- Measurement of weight bearing at the maximal body weight shifted to the limb equipped with Ilizarov fixator without the use of crutches.

Statistical analysis was performed using Statistica 9.0. software. Average, median minimal and maximal values were determined for each set of results, and standard deviation were calculated. In order to determine the level of statistical significance, correlation coefficient was calculated and Student's *t*-test for

dependent variables as well as independent variables and the Shapiro–Wilk test to assess data distribution were employed.

3. Results

Maintenance of relaxed stance – 1 minute maximal value

Test with forearm crutches: In two out of fifteen patients, a high value of 47% body weight was reached with the support of crutches, while the lowest value obtained by one patient was only 6% (average of 24.1%, as compared to 75.9% for the healthy limb). None of our patients was able to equally distribute the body weight between both limbs (i.e., 50% each). Test without forearm crutches: In this set of tests, highest value reached 50% body weight, while the lowest was 3% (average of 26.1%, as compared to 73.9% value obtained for the healthy limb). Three patients were able to support their body weight by the affected limb without crutches at 46% body weight. Differences between healthy and affected limb in the set of tests performed with and without crutches are statistically significant ($p = 0.0002$). On average, using crutches resulted in lower degree of weight bearing on the affected leg than when tested without crutches (2% difference), (Table 3).

Table 3. Statistical analysis of 1-minute maximal value and maximal pressure exerted on the affected lower limb in relaxed stance

	Lower extremity	Mean ± SD (%)	<i>t</i> *	<i>p</i>
The 1-minute maximal values – maintenance of relaxed stance with crutches	With fixator	24.13 ± 13.17	-7.604	0.00002
	Without fixator	75.96 ± 13.17		
The 1-minute maximal values – maintenance of relaxed stance without crutches	With fixator	26.13 ± 15.17	-6.097	0.00002
	Without fixator	73.96 ± 15.17		
Values of maximal pressure exerted on the affected limb during 1-minute test with crutches	With fixator	29.6 ± 16.41	-4.812	0.0002
	Without fixator	70.4 ± 16.41		
Values of maximal pressure exerted on the affected limb during 1-minute test without crutches	With fixator	31.6 ± 16.36	-4.338	0.0006
	Without fixator	68.3 ± 16.36		

Abbreviation: SD – standard deviation.

Maintenance of relaxed stance – maximal pressure exerted on the affected limb during 1 minute test

Test with forearm crutches: Highest value obtained in this set of tests was 59% body weight and lowest – 8%. Average value was 29.6% as compared to 70.4% for the healthy limb. Test without forearm crutches: While highest value in this group reached 57% body weight, the lowest one was 9%. Average value for this set of results was 31.6%, while average value for the healthy limb reached 68.3%. In both tests (with and without crutches), the observed body weight distribution on the healthy limb and the affected limb and maximal pressure exerted on the affected limb reached the level of statistical significance ($p = 0.0002$ and $p = 0.0006$, respectively), (Table 3).

Shifting body weight to the affected limb

Test with forearm crutches: Highest value obtained in this set of tests for the limb equipped with Ilizarov apparatus was 91% body weight, while the lowest was 19%. On average, patients were able to support their body weight on the limb with apparatus at the rate of 53.6%. Test without forearm crutches: The highest value was 78% body weight, while the lowest 11%. On average, the affected limb was supporting the body weight at the rate of 48.26%. Results obtained in tests with and without crutches are not statistically significant ($p = 0.509$). Nevertheless, there is a statistically significant strong correlation between these results (0.803), (Table 4).

Table 4. Statistical analysis of values of shifting body weight to the affected limb

	Mean ± SD (%)	t^*	p	Correlation
Shifting body weight to the affected limb with forearm crutches	53.62 ± 22.06	0.6688	0.509	0.803
Shifting body weight to the affected limb without forearm crutches	48.26 ± 18.19			

Abbreviation: SD – standard deviation.

*Student's t -test for dependent variables.

4. Discussion

Research data published on the Ilizarov technique is usually focusing on the process of bone regeneration [7], [9], [11], [18], [20], while reports concerning patient rehabilitation in this method, and especially axial weight bearing of the affected limb, are rela-

tively scarce [12]. It is surprising, especially when taking into account the importance of proper rehabilitation procedures for the success of distractive osteogenesis treatment [2], [3], [6].

Early introduction of rehabilitation procedures prevents occurrence of post-surgical complications, as well as complications due to the apparatus itself, improves the function of lower limbs, helps to adapt to the new biomechanical conditions, and strongly influences patients' quality of life by recognizing their psychosocial needs [2], [6], [19]. Although patients' rehabilitation in Ilizarov method encompasses a broad spectrum of various therapeutic approaches, nevertheless, a vast majority of reports published to date concentrate on the influence of this procedure on soft tissues, such as e.g., the development of knee contractures [1], [5], [8], [15], [17]. Maybe, the procedures used in physiotherapy led to reduction of pain and increased the confidence and proprioceptive function of individuals to distribute better their weight.

In this report, we describe the impact of rehabilitation on the ability to bear weight on the affected limb equipped with Ilizarov external fixator. Obviously, a long term treatment approach such as Ilizarov method requires a full cooperation and commitment from the patient [6], [7], [11], [19]. The degree of weight bearing by the affected limb will also be influenced by the patients' ability to deal with stress, their overall sense of well-being and acceptance of the new, post-surgery reality. Multitude of possible complications, longevity of the treatment and significant abrogation of the quality of life, especially in the early postoperative phase, make this treatment option very demanding. Therefore, patients' psychological well-being has to become a priority for the entire medical personnel during the intra-hospital phase of the treatment [10], [16].

In order to increase patients' comfort and sense of security, two out of four tests were performed while using forearm crutches. However, it is interesting to note that introducing the crutches did not make a significant difference in the set of tests requiring patients to remain in the relaxed stance, since in both cases (crutches vs. no crutches) the limb with the apparatus was supporting the body weight in almost identical way. However, it could theoretically be expected that, while using crutches, patients would either spare the affected limb supporting themselves more on the crutches, or on the contrary, would feel more secure and therefore, increase the weight bearing on the affected leg. Indeed, the latter occurred when patients were asked to transfer maximal weight on the affected limb. Crutches allowed them to increase the use of the

affected leg to support their body weight. Not significant difference in both cases of tests (crutches vs. no crutches) could be the result of fear of weight on the affected limb.

Data available on the static weight bearing in patients treated with Ilizarov technique is limited [12]. Although the majority of research in this field analyzes primarily the static and dynamic parameters of gait, there is, nevertheless, a clear consensus among authors that Ilizarov method alters the pattern of weight bearing characteristic of each individual. Such alteration is most pronounced within the first days post-surgery and within the distraction phase, when patients are trying spontaneously to avoid overloading the affected limb both while standing and walking. Therefore, the importance of intensive physiotherapy and rehabilitation carried out throughout the entire therapeutic process cannot be overestimated [4], [5], [8], [21].

The Ilizarov method is broadly employed in both orthopedics and traumatology and it is performed not only as a tool for bone lengthening but also in limb axis correction, and in the treatment of pseudoarthrosis, inborn defects of the feet as well as bone fractures [13], [14]. It is conceivable that such diverse group of orthopedic conditions will be characterized by different weight bearing patterns for each of these disorders. For example, patients with inborn uneven leg length are able to burden the operated leg to the higher extent than patients treated with the same method for leg injuries [16].

Dynamometric platform employed in our tests proved to be extremely useful in assessing the efficacy of rehabilitation approaches and their possible adjustments in patients treated with Ilizarov technique. Tests described in this report were performed on the third day after the surgery, when the clinical condition of all participating patients was similar and was not complicated by long-term side effects of the therapy. Performing the tests again within the longer time frame would certainly reveal discrepancies in the results stemming from, e.g., the occurrence of various side effects as well as diversity of rehabilitative approaches employed for each patient after the discharge from the hospital. In contrast to that, the intra-hospital rehabilitation procedures were very similar in each case.

Among many advantages of the dynamometric platform non-invasive character and simplicity of the tests are certainly of crucial importance. Moreover, at any stage of the therapy, patients are able to assess themselves the efficiency and progress of physiotherapy as far as their weight bearing ability is concerned. Dynamometric platform testing has also a potential to become a constitutive part of

physiotherapy protocol, allowing patients to receive the direct feedback by observing the distribution of the pressure in the FOOTPRINT program and work directly to improve these values during the test. Additionally, dynamometric platform testing has a broad variety of uses, e.g., in gait analysis before and after the Ilizarov procedure.

Our study would certainly benefit from testing larger population of patients. Additionally, it would be very interesting to compare data reported here with result obtained in a similar way before surgery as well as during distraction and consolidation phase of the treatment. Research does not take into consideration psychological aspects of this treatment.

5. Conclusions

Patients treated with Ilizarov method are not able to equally distribute the weight between two limbs nor to fully support the body weight on the limb equipped with the apparatus.

Patients treated with Ilizarov method do not achieve one of the early intra-hospital physiotherapy targets before leaving the hospital (equal body weight distribution between both lower limbs and shifting the body weight to the affected limb).

Physiotherapists should pay attention to more effective physiotherapy in respect of weight bearing. Effects of these activities could be estimated before leaving the hospital as a matter of course and become a standard procedure.

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