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Treatment of Congenital Leg Length Discrepancies in Children Using an Ilizarov External Fixator: A Comparative Study

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ABSTRACT

The purpose of this study was to evaluate the influence of intramedullary (IM) alignment used in combination with an Ilizarov external fixation on the healing index (HI) and lengthening index (LI) in the treatment of congenital leg length discrepancies (LLD). This study included 35 patients aged from 3.5 to 19 (average age 10.73) who underwent the equalisation procedure using an Ilizarov external fixator. We compared the duration of the external fixator application, LLD, HI and LI between two groups of children: children in Group I underwent limb lengthening by the conventional Ilizarov technique using an Ilizarov external fixator alone, and children in Group II underwent a combination of Ilizarov technique and intramedullary alignment with two Kirschner wires, introduced through two mini-incisions. We found significant differences between the two groups of patients for duration of external fixator application and HI. Patients with congenital LLD treated with combined method of treatment had benefit from intramedullary alignment due to its better outcome.

Key words: leg length discrepancy, Ilizarov external fixator, children

Introduction

During the last fifty years various operative techniques have been introduced aiming to improve anatomic and functional results in limb lengthening in children. Among those different techniques of progressive lengthening, external fixation is the most often used, especially an Ilizarov external fixator. Lengthening in limb discrepancies based on the principles of Ilizarov^{1–4} have stressed out satisfied results with such technique^{5–7}. It is important to point out that it provides lengthening and correction of deformities in three dimensions. The significant distraction is made possible thanks to the gradual distraction (calothasis) of soft tissues and neurovascular elements¹. An important modification of this technique refers to the module where Ilizarov external fixator and intramedullary alignment would be associated as one procedure^{1,8}. Intramedullary alignment exists in two forms: a rigid nails (Kirschner wires) and a flexible nails (titanium elastic nails)^{9,10}. In comparison to the application of Ilizarov external fixator alone, the combination of the external fixator and intramedullary alignment would bring to the decrease of bone deformity risk during the lengthening period and also decrease a healing period¹¹.

The purpose of this study was to evaluate the influence of the intramedullary alignment with two Kirschner wires associated with an Ilizarov external fixator on the following criteria in congenital limb length discrepancies.

Materials and Methods

Study group

We have evaluated 35 patients (19 girls and 16 boys), aged from 3.5 to 19 years (average 10.73), that were referred to the University Children's Hospital (UCH) for orthopedic corrections, where limb lengthening was performed during a twelve years period, between January 2000–January 2012. The study was approved by Institutional Review Board and followed the principles of good clinical practice. Prior to inclusion in the study parents or legal guardians were informed about surgical procedure and treatment outcome and informed consent was obtained. For diagnosis confirmation initial check-up was done by Board Certified Pediatric Surgeon and Radiolo-

gist. The follow-up was done by Board Certified Pediatric Surgeon, Radiologist and Physiatrist. Only patients that were planned for monosegmental limb lengthening procedures were included in the study. The exclusion criteria included neurological and metabolic etiologies and unreconstructible congenital anomalies. Lengthening was completed with the Ilizarov technique (using an Ilizarov external fixator) with or without intramedullary alignment with two K-wires. The first stage in both groups was the application of the Ilizarov external fixator.

We compared two groups of patients: Group I included patients were lengthening with an Ilizarov external fixator alone (Figure 1) and Group II that included patients where lengthening with combination of an Ilizarov external fixator and intramedullary alignment (Figure 2).

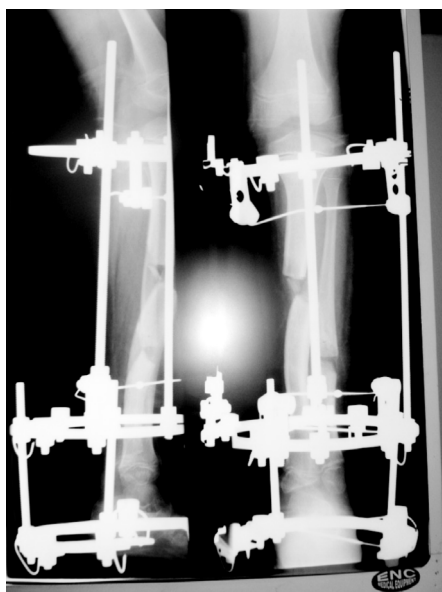


Fig. 1. Patient treated with an Ilizarov external fixator alone.

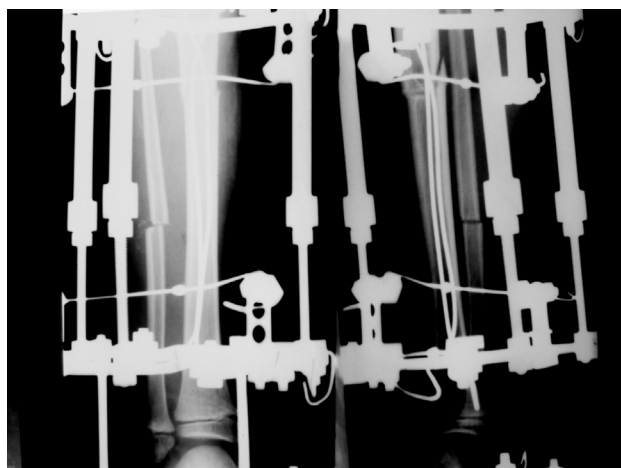


Fig. 2. The combination of Ilizarov external fixator and intramedullary alignment with two K-wires.

The following parameters were evaluated: duration of the external fixator use, healing index (HI), Inequality, Healing Index, Lengthening Index.

Healing index represents the duration of the external ring osteosynthesis required to obtain 1 cm of the lengthening¹². It is expressed as days/cm.

Lengthening index represents the ratio between pre- and post-operative lengthening of the leg segment and it is expressed in cm.

Surgical procedure

In Group II, after the application of the Ilizarov external fixator, K-wires were placed intramedullary. Through two skin incisions, about 1.5–2 cm from the growth plate, two holes were made in the bone, oblique toward the axial plane, that would provide a much easier placing the K-wires. Diameters of the wires ranged were from 2–2.5 mm with the ray of the curvature about 40 degrees. The K-wires are bended in the way that allows assembling two intersecting arches and threw the tibia were positioned at the anterograde direction, pushing them from proximal to distal metaphysis. Two K-wires, one from the medial side and the other from the lateral side, were carefully introduced by rotation and were pushed gently until they reached the opposite metaphysis. The maximum of the curve should be placed near the future osteotomy site. The external tips of the intramedullary wires were bent over 90 degrees to avoid their sliding in the medullary canal during the distraction period. They were placed under the skin to avoid potential skin infections around the K-wires. Diaphysear-metaphysear osteotomy of the bones followed the above mentioned procedure, in both groups; proximal osteotomy of the tibia and distal osteotomy of the fibula, and initial lengthening about 3–5 mm was provided.

Postoperative period

During the postoperative period, in both groups, according to the reference data, the lengthening began on the seventh day^{1,9}. To prevent the eventual onset of infection, in evaluated patients prophylaxis with antibiotics (second generation Cephalosporin's) was prescribed at the time of surgical intervention and over 3 days after. We preserved a limb function by an early joint mobilization about seventh postoperative day. Radiographic assessment was done after every fifteen days in each group. When homogeneous bone regeneration was noticed and confirmed with the radiographic diagnostic tools, the Ilizarov external fixator was removed in both groups and patients were able to walk with partial weight bearing without pain, after the check-up of Board Certified Pediatric Surgeon and Physiatrist. Following removal of the external fixator, a plaster cast wasn't applied. The K-wires were removed when the radiographic appearance of the regenerate was equivalent to the normal adjacent bone.

Statistical interpretation

We have presented the evaluated parameters as mean values (MV) with standard deviation (SD). For estimation of statistical difference between evaluated groups we used students T-test. Statistical significance was set at $p < 0.05$.

Results

We evaluated 35 patients (19 girls and 16 boys), aged from 3.5 to 19 (mean 10.73) years.

For the group of patients who underwent combined Ilizarov external fixator and intramedullary alignment procedure (Group II), we found significant differences in the duration of the external fixator use ($p < 0.01$) and in Healing Index ($p < 0.01$), comparing to the group treated with an Ilizarov external fixator alone (Group I). Concerning inequality and Lengthening Index we found that there was no significant difference between results of two differently conducted surgical procedures (Table 1).

Discussion

In this study we have evaluated the effectiveness of different orthopedic approaches (Ilizarov technique alone and Ilizarov technique with intramedullary alignment with two K-wires) in patients with congenital LLD. The combination of Ilizarov method and intramedullary alignment enables certain advantages of particularly intramedullary alignment to the gradual osteosynthesis improvement. As it is previously stated, the intramedullary alignment with K-wires does not inhibit the endostal regenerate and if an intramedullary vascularization is preserved, the bone regeneration is stimulated due to biological effects of the blood flow redistribution to periosteal structures¹⁴. Further, such technique influences the stabilization by the prevention of translation at the level of the diastasis¹⁵.

We presumed that the progressive sliding of the intramedullary wires through the regenerate during the period of distraction could result in the stimulation of regenerative processes. Thus, to achieve these biological effects, while inserting the K-wires, their curve should be maximally close to the osteotomy on the opposite side from the approach site. These conditions enable positioning the apex of the wires curvature at the level of the growth zone of the regenerate by the end of the distraction period, since the sliding of the wires in the intersection slowly transverses the bone regenerate. The application of the intramedullary K-wires does not disturb the correction of deformities associated with limb length discrepancy; on the contrary, it allows their correction. Finally, there is a possibility to remove the external fixator, leaving the intramedullary K-wires that reinforce the regenerate, thus ensuring a certain degree of stability¹⁵.

The results of our study stressed out that patient with combined treatment had significantly lower duration of the external fixator usage and significantly better Healing Index that is in correlation with above mentioned fact concerning the role of intramedullary alignment aside Ilizarov technique on healing processes^{16,17}.

Aside favorable treatment outcome with combined Ilizarov technique and intramedullary alignment with two K-wires, the study's main limitation refers to the lower number of participants. Therefore, further studies on larger number of participants are needed.

It is worth mentioning that intramedullary alignment respects all the obligatory conditions of the distraction osteogenesis: preservation of the surrounding bone, the periosteum, and intramedullary vascularization respecting all physiological phases during the process of limb lengthening. It preserves the function by an early articular mobilization and weight bearing with respect of all biomechanical rules and improves the quality of life¹⁸.

TABLE 1
MEAN VALUES OF EVALUATED PARAMETERS IN PATIENTS TREATED WITH AN ILIZAROV FIXATOR ALONE (GROUP I) AND COMBINED ILIZAROV EXTERNAL FIXATOR AND INTRAMEDULLARY ALIGNMENT (GROUP II)

Parameters N=35	Categories	Values (MV±SD)	Statistical interpretation
Duration of the external fixator use (days)	Congenital I (N=23)	210.48±67.43	$p < 0.01^*$
	Congenital II (N=12)	133.57±26.44	
Inequality (cm)	Congenital I (N=23)	5.80±2.14	$p > 0.05^*$
	Congenital II (N=12)	6.71±3.94	
Healing Index	Congenital I (N=23)	40.01±16.92	$p < 0.01^*$
	Congenital II (N=12)	24.39±8.21	
Lengthening Index	Congenital I (N=23)	0.30±0.25	$p > 0.05^*$
	Congenital II (N=12)	0.36±0.16	

*student's T-test

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LIJEČENJE PRIROĐENIH NESRAZMJERA U DULJINI NOGU KOD DJECE KORISTEĆI VANJSKI FIKSATOR PO ILIZAROVU – USPOREDNA STUDIJA

SAŽETAK

Cilj ove studije je procijeniti utjecaj intramedularnog (IM) poravnanja korištenog u kombinaciji s vanjskim fiksatorom po Ilizarovu na indeks cijeljenja (HI) i indeks produljenja (LI) kod liječenja prirođenih nesrazmjera u duljini nogu (LLD). Ova studija uključivala je 35 pacijenata u dobi od 3,5 do 19 godina (prosječna dob 10,73) koja su podvrgnuta proceduri ujednačavanja koristeći vanjski fiksator po Ilizarovu. Usporedili smo trajanje primjene vanjskog fiksatora, LLD, HI i LI među dvjema skupinama djece: djeca u skupini I su bila podvrgnuta produljenju noge konvencionalnom tehnikom po Ilizarovu, koristeći samo vanjski fiksator po Ilizarovu, a djeca u skupini II su bila podvrgnuta kombinaciji tehnike po Ilizarovu i intramedularnog poravnanja s dvije Kirschnerove žice uvedene kroz dva malena kirurška reza. Pronašli smo značajne razlike među dvjema skupinama pacijenata u trajanju primjene vanjskog fiksatora i HI. Pacijenti s prirođenim LLD liječeni kombiniranom metodom imali su dobiti od primjene intramedularnog poravnanja zbog boljeg ishoda.