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Role of Ilizarov external fixator in the treatment of long-standing knee flexion deformity in adults: A prospective cohort study

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ABSTRACT

Background:

One of the major disabilities of the lower limb is fixed knee flexion deformity. Post-polio residual paralysis is the main etiology, but there are others. This study evaluated the outcome of treatment of long-standing fixed knee flexion deformity with the Ilizarov external fixator without soft-tissue intervention or osteotomy in a certain age group.

Methods:

Thirty patients (33 knees) with knee flexion deformity were enrolled in this study. There were 11 women and 19 men. Three patients had bilateral lower limb affection. The etiology was post-polio residual paralysis in 11 patients (14 knees), four patients had brain insult, eight patients had post infectious etiology, and seven patients had failure of open reduction and internal fixation of tibial plateau fractures. An Ilizarov fixator was applied in all patients for deformity correction with no soft-tissue release or osteotomies.

Results:

The mean age of the patients was 28.7 yr (18-55 yr), the mean preoperative flexion knee angle was 77.87 degrees (50-130 degrees). The mean preoperative arc of motion was 17.1 degrees (0-50 degrees), the mean time since the deformity was well established was 9.4 yr (4-30 yr), the mean time needed for correction of the deformity was 49.2 days (27-120 days) at the end of the procedure. All patients achieved full correction of the deformity.

Conclusions:

The Ilizarov external fixator is an effective tool in the treatment of severe long-standing fixed knee flexion deformity in adults with minimal complications and good outcomes.

Level of Evidence:

Level II.

Key Words

Ilizarov, long-standing, flexion, deformity

INTRODUCTION

Fixed knee flexion deformity is considered a major cause of disability. Depending on its severity, it increases the load on the quadriceps muscle and can be cause an individual to be nonambulatory.[1] Post-polio residual paralysis is one of the main causes of this deformity, but other causes are infections, scarring from burns, rheumatoid arthritis, neuromuscular disorders, and congenital disorders.[2,3] Several procedures have been reported to correct fixed knee flexion deformity, including operative modalities, such as soft-tissue release, tendon lengthening, posterior capsulotomy, osteotomy, femoral shortening, and arthrodesis, and nonoperative modalities, such as serial casting.[4–8] Acute correction of a flexion deformity can lead to serious complications such as neurovascular compromise, skin necrosis, joint subluxation, and recurrence.[9,10] Gradual correction of a fixed knee flexion deformity using the Ilizarov external fixator, with or without soft-tissue release, has been reported with a great success rate and few reported complications.[4,11,12]

The purpose of this study was to evaluate the effectiveness of the Ilizarov circular fixator in the treatment of adult patients with long-standing knee flexion deformity, without using any soft-tissue release or bony osteotomy. Our hypothesis was that such deformity could be corrected using the Ilizarov external fixation without the need for any open procedures.

MATERIALS AND METHODS

Ethical Review and Study Design

This prospective cohort study was approved by the ethical committee of the Benha University (approval: Orth27-2009) and was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. All patients signed an informed consent after clear explanation of the surgical procedure.

Patient Enrollment

Between February, 2010 and May, 2013, 30 patients (33 knees) with knee flexion deformity were consecutively enrolled. There were 11 women and 19 men. Twelve had right side deformities and 15 had left side. Three patients had bilateral lower limb affections. The etiologies of the flexion knee deformity are listed in Table 1.

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TABLE 1. Etiologies of fixed flexion deformity

Patients	Etiology
11 patients (14 knees)	Post-residual polio paralysis
4 patients	Post brain insult
8 patients	Post infecti
7 patients	Post failure of open reduction and internal fixation of tibial plateau fractures

All patients were examined clinically and radiographically. The surgical details and the postoperative procedure and follow-up were discussed with the patients and their relatives. Inclusion criteria were adult patients with fixed knee flexion deformity of more than 3 yr duration.

Surgical Technique

Under spinal anesthesia and complete aseptic conditions, the patient was placed supine on an orthopaedic table with access to an image intensifier. The femoral component was applied to the distal and middle parts of the femur perpendicular to the bone. The component was composed of a proximal 90-degree or 120-degree arch and a distal ring of appropriate size. The arch was fixed to the femur with 5-mm or 6-mm half pins or Schanz screws, and the distal complete ring was fixed to the supracondylar region with mm Kirschner wires.

The tibial component, which consisted of two complete rings of appropriate size, was fixed to the tibia by 2-mm Kirschner wires augmented by 5-mm half pins in the vertical plane to the bone.

A unidirectional hinge was placed to connect the femoral and the tibial components; position of the hinge was on the lateral side and slightly anterior to the center of rotation of the knee joint to prevent posterior subluxation of the tibia.

Two posterior distractor rods were placed on bot e medial and lateral sides. At first, the distractor was placed between the femoral ring and the distal tibial ring because the proximal tibial ring was overcrowded with the femoral ring. Eventually the distractor was placed between the femoral ring and the proximal tibial ring to increase its leverage.

ostoperative Device Distraction and Follow-up

Patients were discharged from the hospital on the third or fourth day postoperatively after full neurological and vascular examination. The patients received parenteral antibiotics (third generation cephalosporins) analgesics (nonsteroidal antiinflammatory medication), and antiedematous drugs (alphachymotrypsin). Plain anterolateral radiographs were obtained, and the patients were educated about care of the fixator and the distraction technique.

Distraction egan 7 days postoperatively by the patient or his relatives at a rate of 1 mm per day. We demarcated the nuts, and the hinge was unlocked. Patients returned the first week postoperatively for clinical examination, pin care, to check construct stability, and to begin distraction.

Patients were evaluated in the outpatient clinic every week until the deformity was fully corrected. At every office visit, radiographs were obtained to detect the degree of joint distraction or subluxation. Medication for pain was prescribed, and psychological support for the patient was obtained by a psychotherapist. The progress of deformity correction was assessed, and the hinge position changed depending on the progress of of the deformity correction. We followed the rule of similar triangle or concentric circles to detect and report progress in deformity correction and knee extension.[2,9]

Distraction was continued until the knee was fully extended. The hinge was then locked, and the apparatus was left for ab 8 wk, with the patient full weight bearing. The apparatus was removed, and the patient was put in a long leg cast for 4 wk. The patient walked in a hinged brace for another 4 wk, during which time physiotherapy was initiated.

Patients with post-polio residual deformity continued to walk in a brace because of varus-valgus instability.

Outcome Measures

The mean time to deformity correction, range of motion, ambulation, knee stability, and complications were documented. Progress in deformity correction was measured by the authors with a goniometer, and the mean of the two measures was considered.

RESULTS

The mean age of the patients was 28.7 yr (18 to 55 yr). The mean preoperative knee flexion deformity angle was 77.87 degrees (50 to 130 degrees), measured by goniometer (Table 2). The mean preoperative arc of motion was 17.1 degrees (0 to 50 degrees). The mean time since the deformity was established was 9.4 yr (4 to 30 yr). The mean time needed for correction of the deformity was 49.2 days (27 to 120 days); all patients remained in the fixator for 2 mo after full correction.

All patients had achieved full correction at the time of fixator removal. The follow-up period ranged from 2 to 4.5 yr. No neurovascular complications occurred during correction or in the postoperative period. Recurrence of the deformity was observed in three patients during the first 18-month follow-up. The degree of recurrence was between 5 to 17 degrees. It was noticed that these three pat s had brain insult as an etiology for the flexion deformity. Pin track infection occurred in all patients and was treated with oral antibiotics every 12 hr and pin site care with antiseptic solution until the infection subsided.

The mean postoperative arc of knee movement was 36.1 degrees (0 to 90 degrees). Mild subluxation was reported in four patients; they were able to walk with a knee brace. Two patients with post-polio residual paralysis had mild valgus knee instability, for which a brace was prescribed.

TABLE 2. Severity of fixed flexion deformities

Number of patients	Degree of deformity
10 patients	30-60 degrees
17 patients (19 knees)	61-90 degrees
3 patients (4 knees)	91-130 degrees

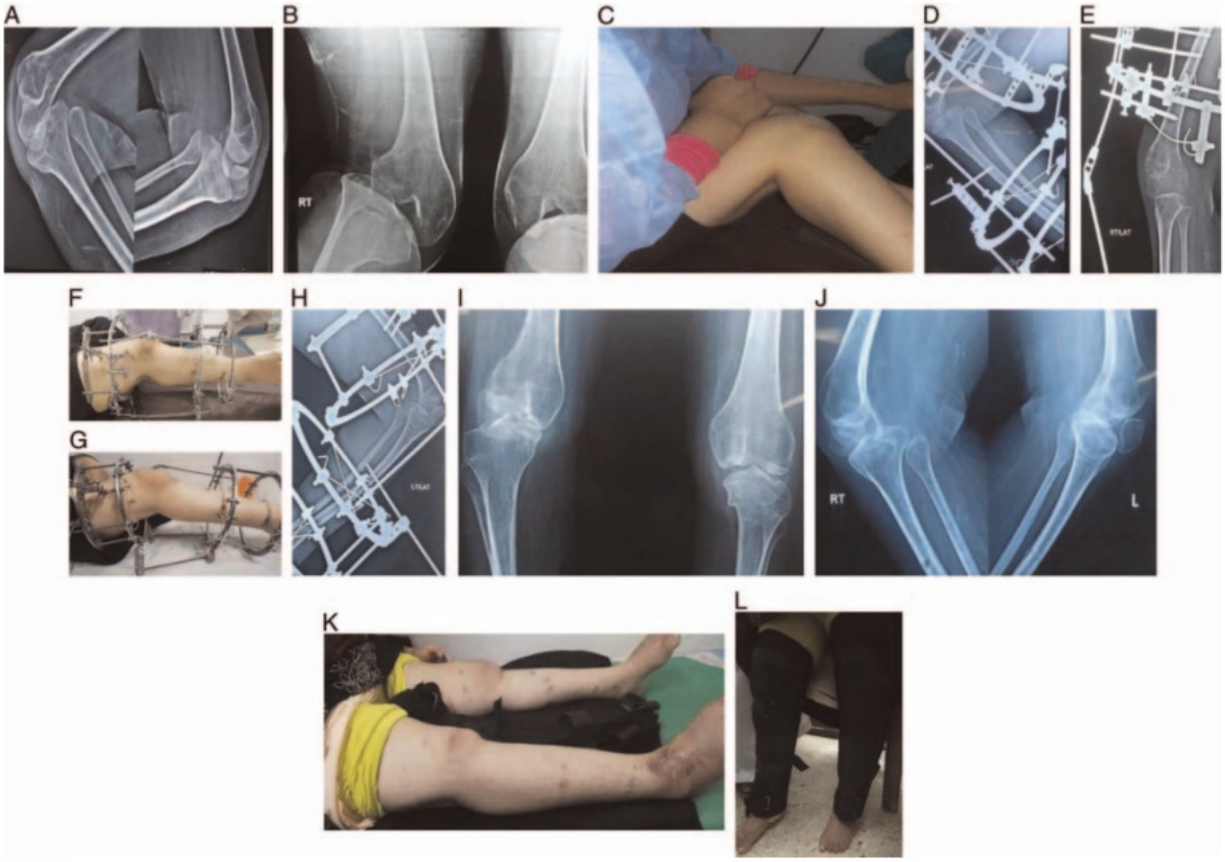

FIGURE 1. (A and B) Preoperative lateral and anteroposterior radiographs of both knees showing deformity. (C) Clinical photo. (D) Lateral view of right knee during correction. (E) Lateral view showing full correction of right knee. (F) Clinical photo of right lower limb after full correction with the Ilizarov external fixator in place. The hinge is in the lateral position. (G) Clinical photo showing left knee fully corrected. The hinge is in the medial position. The right leg is in plaster after the ankle arthrodesis. (H) Lateral view of the left knee during correction. (I) Anteroposterior view of both knees during correction. (J) Lateral view during correction, showing arc of motion. (K) Clinical photo showing full correction of the knees and scar from right ankle arthrodesis. (L) Clinical photo showing patient standing with knee supports. L, left; LAT, lateral view in x rays; LT, left side; RT, right side.

During the follow-up period, all nonambulant and wheelchair-bound patients became ambulant with knee support and two crutches in the first year. Thereafter, patients could walk without crutches and with knee support.

Case Presentation

A 37-year-old woman presented with bilateral fixed knee flexion deformity (Figure 1). The deformity was well established (30 yr). The etiology of the deformity was post-polio residual paralysis. The flexion deformity angle in the right knee was 100 degrees, while in left knee was 110 degrees. The arc of motion in both knees was 40 degrees in the right knee and 25 degrees in the left knee. For ambulation, the patient resorted to crawling. The right knee underwent treatment first. The Ilizarov external fixator was applied to correct the fixed flexion deformity, without soft-tissue release or osteotomies. After full correction, the apparatus was left in position for 2 mo. At the time of the apparatus removal, right ankle arthrodesis was performed. The left knee underwent treatment 2 mo later using the same technique. At the end of the procedure and after a 3-year follow-up, the patient could walk with knee supports and crutches in the first year then later without crutches. There was mild valgus instability in both knees, but with knee supports, there was no impact on the outcome.

DISCUSSION

The aim of treatment of fixed knee flexion deformity is to obtain a straight knee with a useful, painless range of motion. Many attempts have been described to solve such problems, as such a deformity hinders physiologic ambulation.[13] Ford and Lovelt[14] described hamstring tenotomy and serial cast manipulation, where others recommended division of the tensor fascia lata muscle to facilitate the correction and posterior capsulotomy. Abraham *et al.*[4] recommended transfer of the hamstring muscle tendons to the patella.

In 1970 Cornner[14] reviewed 19 patients with knee flexion deformity caused by post-polio residual paralysis. The procedure was a division of the hamstring tendons, iliotibial band,

TABLE 3. Results of other studies for comparison

	Hosney and Fadel[9]	Vishnu and Reddy[2]	Ihab[17]
Methodology	50 patients (71 knees) Out of 50, 29 were unilateral and 21 bilateral Etiology was arthrogryposis multiplex congenita, tibial hemimelia, sacral agenesis, poliomyelitis, posttraumatic and congenital short femur	49 patients (59 knees) Mean age was 16.5 yr, (4-24 yr) Etiology: Post-polio residual paralysis in 38 patients, polio-like illness in 1 patient, multiple congenital contracture in 3 patients, meningocele in 2 patients, femoral focal deficiency in 1, post-septic knee in 2 and posttraumatic in 2 patients	8 patients, severe type I flexion knee deformity (associated joint destruction and fibrous ankylosis). Etiology was juvenile rheumatoid arthritis in 4 patients Infection after ORIF of tibial plateau fracture in 3 patients. Repeated hemarthrosis in 1 patient
Technique	Gradual correction of flexion knee deformity using Ilizarov principals No soft-tissue release was performed in any patient. Osteotomy was performed in 2 patients with arthrodesed knees	Gradual correction of the knee deformity by Ilizarov circular fixator without soft-tissue release	Gradual correction of the knee deformity by Ilizarov circular fixator without soft-tissue release
Results	Mean follow-up was 3.7 yr (1-8 yr), 18 of 20 preoperatively non ambulant became ambulant Mean angle of maximum extension to maximum flexion improved from operative 68 degrees (25-140 degrees) to average 3.5 degrees (0-20 degrees). Average time in fixator was 4 mo (1.5-10.5 mo) Knee total arc of motion still unchanged in the first 42 patients, with mean 40 degrees (0-66 degrees) preoperative to 52 degrees postoperatively. The last 8 patients with marked improvement, the mean preoperative arc was 40 degrees (10-70 degrees) corrected to 67 degrees, (35-110 degrees). Polio patient could walk with knee-ankle-foot orthosis The nonambulant 18 patients could walk (15 with cruches and 3 without)	The mean preoperative flexion knee deformity angle was 71 degrees (10-150 degrees). The follow-up period after removal of fixator was range (2 mo-6 yr). Correction of the flexion knee deformity near normal in all patients	The mean preoperative flexion knee deformity was 67.5 degrees (50-80 degrees). Full correction was achieved in all patients at early postoperative follow up. Follow up was 12-36 mo
Complications	Pin track infection was found in all patients. Five patients had recurrence. Fracture related to treatment occurred in 7 patients. Knee subluxation occurred in 3 patients. Knee stiffness was present in 2 patients	Recurrence occurred in 9 patients less than 20 degrees Recurrence more than 20 degrees developed in 3 patients. Pin track infection was present in 76%. Knee subluxation occurred in 25.4%. Stress fracture was present in 15.2%. Progressive equinus deformity was developed in 13.6%	Six patients developed deformity recurrence with mean angle of 11.25 degrees (5-25 degrees)

	Gaurav and Vilas[10]	Damsin and Ghanem[11]	Current study
Methodology	Prospective study over 4 yr, conducted on patients of age group 11 to 15 yr old 26 patients, (39 knees), with fixed flexion knee deformity (FFD) with soft tissue contracture without ankylosis 9 patients had unilateral deformity 9 patients had bilateral deformity post polio residual paralysis, 4 patients had congenital webbing, 4 patients had triple deformity 7 knees had FFD (30-60) degrees 28 knees had FFD (60-90) degrees 4 knees had FFD (90-120) degrees	11 patients, 13 knees 6 boys and 5 girls Mean age at the time of operation was 12 yr (1.7-18.8 yr) All patients were able to walk preoperatively Posterior sublaxation was present in 6 knees Flexion contracture deformity range 90-150 degrees Different aetiologies were reported	30 patients, 33 knees with flexion knee deformity 11 females and 19 males, 12 right side, 15 left side and 3 patients with bilateral lower limb affection Post-polio residual paralysis in 11 patients (14 knees), 4 patients had brain insult, 8 patients post infection 7 patients post failure of open reduction and internal fixation (ORIF) of tibial plateau fracture

TABLE 3. (*Continued*)

	Gaurav and Vilas[10]	Damsin and Ghanem[11]	Current study
Technique	Soft tissue distraction by Ilizarov external fixator following Ilizarov principles without any osteotomies or soft-tissue dissection	Soft tissue distraction by Ilizarov external fixator following Ilizarov principles Tenotomy of hamstring muscles was done in 3 patients After correction: 5 knees were arthrodesed Total knee arthroplasty was planned in 1 patient	Soft tissue distraction by Ilizarov external fixator following Ilizarov principles without any osteotomies or soft tissue dissection
Results	Distraction was continued from 6-12 wk, all patients achieved full correction except, 1 patient of FFD (90-120 degrees) group had residual deformity 10 degrees 2 patients with congenital webbing had residual deformity 20 degrees The mean arc of motion still unchanged	Average operative time was 140 min Average correction time was 54 days (5-10 wk) Average fixation time was 105 days, (8 weeks-1 yr) The mean corrected angle of knee flexion deformity was 6.5 (0-20) degrees postoperative Mild varus instability was present in 1 patient 3 patients out of 6 who had posterior subluxation developed full correction at the end of follow-up period	The mean preoperative flexion angle knee deformity was 77.87 (50-13) degrees The mean preoperative arc of motion was 17.1 (0-50) degrees The mean time since the deformity was well established was 9.4 yr, (4-30 yr) The mean time needed for correction of the deformity was 49.2 days, (27-120) All patients remained in the fixator for 2 mo after full correction
Complications	1 patient had stress fracture in the left femur Pin track infection in 2 cases	Acute pain due to stress fracture in 3 knees Pin track infection in 5 cases Paralysis of the common peroneal nerve was seen in 1 patient Physeal injury developed in 3 knees Recurrence of deformity was seen in 4 patients after average follow-up period 1.7 yr	Mild subluxation occurred in 4 patients Recurrence of the deformity was observed in 3 patients Pin track infection was present in all patients

Comparison between the current study and other similar studies.

and posterior capsular release. He found that the satisfactory result was related to the preoperative degree of tibial suluxation and not the degree of flexion deformity. He also added that posterior capsulotomy and hamstring tenotomy do not facilitate the process of correction and may predispose to tibial subluxation during the correction. In 1977 Abraham *et al.*[4] reported remarkable success in the treatment of flexion deformity of the knee in patients with myelomeningocele by transplantation of the hamstring tendons to the femur or to the patella after elongation or division. In 1982 Grujic and Aparisi[15] treated 31 children with knee flexion deformity due to neurological disease by distal hamstring tendon release; the results were satisfactory at 5-year follow-up. Some authors performed bony procedures for deformity correction. Leonge *et al.*[6] performed a supracondylar femoral osteotomy in 82 patients with fixed knee flexion deformity. All patients improved and were satisfied despite a high number of recurrence in 30 patients and residual deformity (5 to 20 degrees) in 12 patients. Qiang *et al.*[16] published a case report on the treatment of an adult case of flexion deformity of the knee of more than 80 degrees, which was caused by adult-onset Still's disease. The patient underwent bilateral total knee arthroplasty followed by serial casting to correct the residual deformity after arthroplasty; the result was satisfactory.

Many other authors believe that acute correction of knee flexion deformity, especially long-standing deformities, by soft-tissue release or osteotomies is associated with a high rate of complications (neurological, skin, vascular insult), and a high rate of recurrence, residual deformity, weakness of the posterior element of the knee joint that allows posterior subluxation of the tibia.[2,7,9,11,17] Several authors have treated patients of different age groups and with different degrees of fixed flexion deformities, caused by different etiologies, using the Ilizarov external fixator with or without soft-tissue release or osteotomies and bone lengthening.[2,7,9–11,17] Results are comparative to the current study as demonstrated in Table 3.

Our study discussed the effectiveness of the Ilizarov external fixator in the treatment of long-standing knee flexion deformity without any soft-tissue or bony procedures. The point of strength of the current study is the long-standing deformity in all patients (more than 3 yr) as well as the variety of etiological factors. Limitations of the study include the relatively small number of patients and the lack of a functional outcome score. However, the main goal of the study was the assessment of deformity correction.

CONCLUSIONS

We concluded that the Ilizarov external fixator without any soft-tissue release, tendon lengthening, or osteotomy is effective in the treatment of long-standing adult fixed knee flexion deformity in the early and late follow-up period.

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