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Original Research Article

Gradual distraction for treatment of severe knee flexion contractures using the Ilizarov's apparatus

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ABSTRACT

Background: Knee flexion contractures result in a significant amount of functional disability due to reduced mobility and limb length discrepancy. Treatment options include non-surgical methods like serial casting, dynamic splinting and traction or surgical methods like osteotomies and soft tissue procedures. External fixation has emerged as a highly successful means of achieving controlled gradual correction of joint contractures with low rates of complications including recurrence. The aim of this study is to evaluate the functional outcome in terms of residual deformity and change in ambulatory status following correction using the Ilizarov's apparatus.
Methods: 12 patients with knee flexion contractures ranging from 20°-70° underwent correction using the Ilizarov's external fixator (IEF). The use of simple mathematic formulae enabled us to calculate and estimate the rate and duration of distraction. End results were assessed at one year by the residual contracture as: Excellent: 0-5°, Good: 6-15°, Fair: 16-30° and Poor: >30°.
Results: The functional assessment was graded as excellent in 7, good in 4 and fair in 1 out of 12 patients. All patients were independent ambulators and only 1 out of 12 patients required an additional orthosis for maintenance of the correction.
Conclusions: The IEF is a safe and precise modality even for the most complex contractures of the knee. Accurate placement of the hinges along the center of rotation of the knee avoids undue subluxation of the tibia during correction. In order to ensure a low rate of complications, it is imperative to have a detailed pre-operative plan and all principles of fixation should be meticulously adhered to.

Keywords: Knee contractures, Flexion deformity, Gradual distraction, Ilizarov apparatus

INTRODUCTION

The definition of joint contractures comprises of a limitation of passive range of motion.[1,2] Knee flexion contractures result in a significant amount of functional disability due to reduced mobility and leg length discrepancy. They occur commonly in conditions like arthrogryposis multiplex congenita (AMC), juvenile rheumatoid arthritis (JRA), congenital pterygium, spina bifida, hemophilic arthropathy, poiliomyelitis and cerebral palsy and also secondary to trauma, infective arthritis, burns and prolonged immobilisation. They result in an inability to walk normally, dependency on assistive devices, attendant care, and risk of bed confinement. Attempts at stretching a joint following development of a contracture are usually unsuccessful due to retraction of soft tissues, associated pain and possible bony incongruity. Over time, the contractures gradually

progresses to a state of irreversibility resulting in substantial impairment of activities of daily living. Ultimately a surgical intervention is deemed necessary to achieve the goals of restoring mobility and function.

Treatment options include non-surgical methods like corrective serial casting and dynamic splinting or surgical methods like osteotomies and soft tissue procedures. Guided growth with hemi-epiphysisodesis of the anterior distal femur has been used in the successful correction of knee flexion deformities in skeletally immature individuals.[3] Acute correction of flexion contractures often results in undesirable and potentially devastating complications like skin necrosis, vascular compromise, nerve palsies, hypertension and recurrence.[4] External fixation has emerged as a highly successful means of achieving gradual correction of joint contractures with low rates of complications including recurrence.[5] Gradual deformity correction in the form of external fixation is certainly advantageous in avoiding stretch damage to the neurovascular structures at risk and the magnitude of correction no longer becomes an obstacle. Moreover, by creating a permanent elongation of soft tissues, the chances of recurrence of the deformity are minimized. The aim of this study was to evaluate the functional outcome in terms of residual deformity and change in the ambulatory status following correction using the Ilizarov's apparatus.

METHODS

This prospective cohort study was conducted at the department of Orthopaedics, Armed Forces Medical College, Pune between 2017 to 2019.

12 patients (10 males and 2 females) with knee flexion contractures, age ranging from 6 years to 50 years were included in the study. Of the 12, 2 were post-burns contractures, 1 was a case of multiple epiphyseal dysplasia (MED) with a fixed flexion deformity (FFD) of the knee following surgery for a genu valgum deformity, 1 was a case of congenital pseudoarthrosis of tibia with a post-operative flexion contracture of the knee, 4 cases of post-infective arthritis sequelae, 2 cases of post-traumatic knee flexion deformity and 2 with arthrogryposis multiplex congenita. The average flexion deformity ranged from 20° to 70°.

Inclusion criteria

Patients with FFD knee either congenital or acquired, passive correction of deformity not possible, no active infection/signs of infection, ambulation affected because of the deformity were included.

Exclusion criteria

Patients excluded from the study were cases of neuromuscular imbalance which warranted the need for additional procedures like tendon transfers or osteotomies.

Study tools: Ilizarov's circular external fixator.

Study methods

All patients underwent a standard orthopaedic and neurological examination to rule out any neuro-muscular imbalance. The flexion deformity was measured clinically using a goniometer and recorded. Radiological assessment included sagittal plane imaging with the patient bearing full weight and the extremity placed perpendicular to the beam axis. Frontal plane imaging was done similarly with blocks of different sizes placed under the shortened limb to compensate the shortening. In most cases we used long 51 inch cassette with the X-ray source at a distance of 10 feet (teleroentgenogram). For the others, an orthoroentgenogram, in which a 105 cm, 35 cm wide with 5 cm grid cassette was placed behind the standing patient and 3 images focussed at the hip, knee and ankle were acquired and integrated into a single full length image, was used.[6] From these images, the following parameters were obtained to analyse the deformities: mechanical axes, anatomic axes, mechanical axis deviation (MAD), joint orientation lines and malalignment test.[7,8] The malalignment test were conducted to identify where the deformity was located. This was done by analysing the following angles such as posterior distal femoral angle (PDFA) (normal range: 79°-87°), posterior proximal tibial angle (PPTA) (normal range: 77°-84°) and anterior distal tibial angle (ADTA) (normal range: 78°-82°).

Flexion contractures were assessed by drawing the anterior cortical lines of the femur and tibia and measuring the angle formed between the two intersecting lines. The above mentioned radiographic analysis was crucial to confirm that the flexion deformities were purely due to soft tissue contractures and there was no element of bony deformity.

Surgical technique

The apparatus consisted of 2 rings above the knee and 1 or 2 rings below the knee joint. The rings were placed perpendicular to the bone. For skeletally immature individuals, care was taken to place the wires intra-epiphyseally so as not to damage the growing end of the bone. Failure in doing so would result in physeal separation due to the unyielding nature of the soft tissues and the fibrosis within the joint.[9]The rotational centre of the hinges were placed at the centre of rotation of the knee which roughly corresponds to the intersection of a line drawn along the posterior femoral cortex and the Blumensaat's line.[10] A distraction assembly consisting of 1 or 2 distractors was placed on the concave side of the deformity. The rate and duration of distraction was calculated using the law of 'similar triangles'.[8,9]

Distraction was initiated on the second post-operative day.

Follow-up

Patients were followed up bi-weekly with X-rays to monitor progress and to watch for any joint subluxation until correction. The goal of the procedure was to achieve full correction i.e., neutral to 10°of hyperextension. The fixator was retained for double the time period required to achieve correction following which an orthosis or brace was applied for an addition 1-3 months along with gradual assisted range of motion exercises. At the end of 1 year, a final assessment was undertaken to look for any recurrence of deformity.

Primary outcome assessment

End results were assessed by recording the final residual contracture at the end of 1 year as: excellent: 0-5°, good: 6-15°, fair: 16-30° and poor: >30° as well as improvement in the ambulatory status of the patient.[11]

Statistical analysis

The paired t-test was used to evaluate the parametric data before and after the surgery. Significance was set at p value <0.05.

Figure 1: (A) Fixed flexion deformity of 70° with further flexion up to 120°; (B) standing, weight bearing radiographs showing multiple epiphyseal dysplasia with B/L medial sided hemi-epiphysisodesis done with RT side implant removal done, amount of flexion deformity in RT knee: 70°; PDFA: 89°; PPTA: 79°; (C) intra-op C arm images showing intra-epiphyseal placement of wires; (D) Ilizarov frame with distraction hinges in-situ; (E) postop radiograph with illustration of triangles used to calculate rate and duration of distraction; (F) evolutionary sequence of correction; (G) final correction after removal of the fixator.

Figure 2: (A) Correction of knee FFD in a case of congenital pseudoarthrosis of tibia; (B) correction of knee FFD in a case of post-traumatic knee stiffness.

RESULTS

The mean pre-operative flexion deformity was 52.5° with a range of 20° to 70°. The mean residual deformity at the end of 1 year was 7.08° with a range of 0° to 20°. The difference between pre-operative and post-correction flexion deformity was statistically significant ($p<0.0001$). The functional result obtained was graded as excellent in 7, good in 4 and fair in 1 out of 12 patients. Most patients were able to carry out their activities of daily living without any difficulty including independent, unassisted ambulation and squatting. Only 1 out of 12 patients required a supportive orthosis at the end of 1 year.

Complications

Minor complications included pintract infections and CRPS (complex regional pain syndrome) which responded adequately to conservative measures. There were no incidences of nerve palsies (esp. common peroneal nerve), vascular injuries, skin necrosis, physeal injuries or knee subluxations.

Table 1: Demographic characteristics.

Parameters		No. of patients
Age (years)	5-15	4
	16-30	2
	31-60	6
Sex	Male	10
	Female	2
Affected knee	Left	5
	Right	7
Pre-operative diagnosis	Post burns contracture	2
	Multiple epiphyseal dysplasia with FFD knee	1
	Congenital pseudoarthrosis of tibia with FFD knee	1
	Post infective arthritis sequelae	4
	Arthrogryposis multiplex congenita	2
	Post-traumatic knee flexion deformity	2

Table 2: Primary outcome.

Pre-op flexion deformity (degrees) (Mean±SD)	Residual deformity at 1 year (degrees) (Mean±SD)	P value
52.50±18.02	7.08±5.41	<0.0001

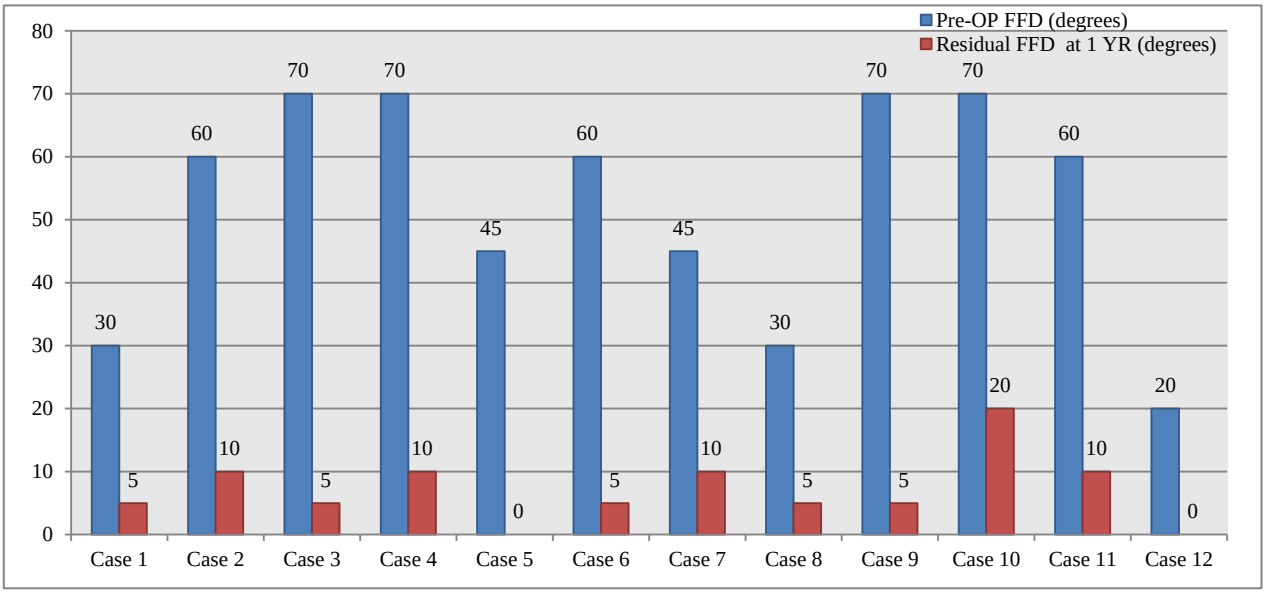

Figure 3: Pre-op and residual FFD of 12 subjects.

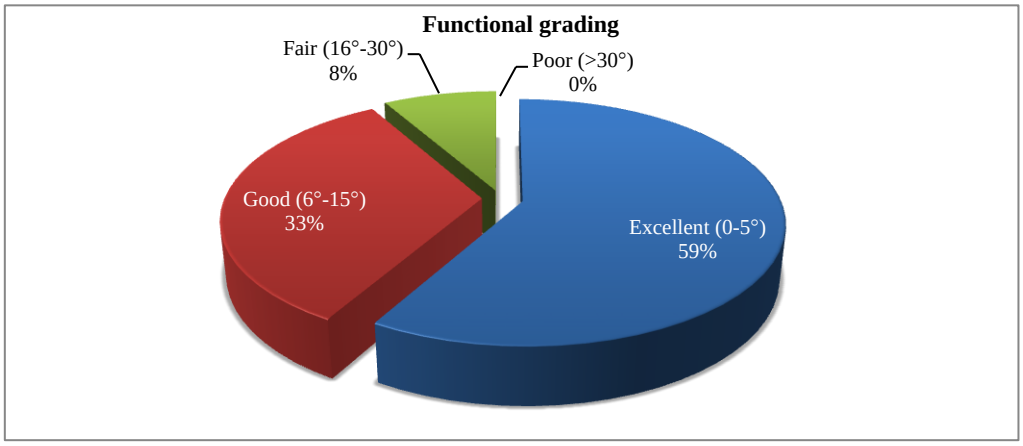

Figure 4: Representation of primary outcome assessment of study subjects.

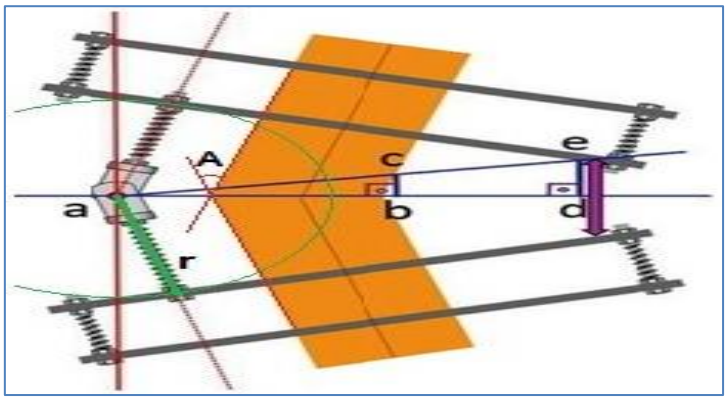

Figure 5: Calculation of amount of distraction using the law of similar triangles.[8-10]

For calculation of correction time, Time=Distance/Rate of distraction, Distance = $2\pi \frac{rA}{360}$, where r=radius, 2πr=length of circle's circumference and A=deformity angle; Example: See Figures 1 E and 5; The triangles abc and ade are similar, hence ab/ad = bc/de (bc=desired rate of distraction on the concave side of deformity (accounting for structures at risk)=1mm/day; ab=distance of concave cortex from distraction hinge= 4 cm and ad=distance of distraction assembly from distraction hinge=8.5 cm (ab and ad calculated from radiographic measurements)), Calculations from the above formula, de=2.125. Hence, Rate of distraction= 2 mm/day.

DISCUSSION

Previous methods of treating fixed flexion deformities of the knee included serial casting, traction, posterior soft tissue release, osteotomies and femoral shortening.[12] The circular external fixator of Ilizarov is an improvement over the previous methods with the advantage of gradual correction thereby avoiding the drastic complications of acute correction and the ability to simultaneously correct associated foot and ankle deformities and limb length discrepancies.

In a study by Balci et al, 6 patients with knee flexion deformities secondary to chronic haemophilic arthropathy with a mean FFD of 45° underwent correction using the Ilizarov fixator. At the end of 8 years, the mean residual FFD was 10° and the amount of correction was statistically significant ($P<0.05$).[13] Hosny and Fadel treated 50 patients of knee flexion deformities with the circular external fixator. The mean angle of maximum extension to maximum flexion improved from a preoperative average of 68° to an average of 3.5° after fixator removal. At the end of 1 year, 18 of 20 of the preoperative non-ambulatory patients who had bilateral surgery were able to walk.[14] Vulcano et al treated 21 patients with knee flexion contractures using the Ilizarov's fixator. The mean ROM at the end of 13 months was −10° extension (range, 0°-−50°) and 64° flexion (range, 20°–100°). The difference between pre and post-operative ROM was statistically significant ($p<0.05$). Also most patients were able to ambulate with few or no walking aids.[5] The results of our study were similar to the above studies. The mean residual contracture at the end of 1 year was 7.08° and the correction attained was significant ($p<0.05$). Only 1 out of 12 patients had a recurrence with difficulty in ambulation which was supplemented by an orthosis. The incidence of complications was low.

Limitations of the study

The limitations of our study include a small number of subjects, relatively short period of follow-up and the lack of a standardized method of analysis of functional outcome.

CONCLUSION

The present study confirms the fact that gradual distraction using a circular external fixator is a safe and effective technique in the management of flexion contractures of the knee. The procedure can be carried out by itself or along with a soft tissue release in a safe and precise manner even on the most complex deformities. Accurate placement of the hinges along the center of rotation of the knee avoids undue subluxation of the tibia during correction. The use of simple mathematic formulae can enable us to calculate and estimate the rate and duration of distraction. It is crucial to maintain the post-operative correction with braces for at least 1-3 months, depending on the severity of the contracture. In order to ensure a low rate of complications, it is imperative to conduct a detailed pre-op evaluation, formulate a plan for correction and all principles of fixation should be meticulously adhered to.

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REFERENCES

1. Halar EM, Bell KR. Immobility. In: DeLisa JA, Gans BM (eds). Rehabilitation Medicine: Principles and Practice. Philadelphia, PA: Lippincott-Raven; 1988: 1015–1034.
2. Trudel G, Uhthoff HK, Brown M. Extent and direction of joint motion limitation after prolonged immobility: an experimental study in the rat. Arch Phys Med Rehabil. 1999;80:1542–7.
3. MacWilliams BA, Harjinder B, Stevens PM. Guided growth for correction of knee flexion deformity: A series of four cases. Strategies Trauma Limb Reconstruction. 2011;6:83-90.
4. Heydarian K, Akbarnia BA, Jabalameli M, Tabador K. Posterior capsulotomy for the treatment of severe flexion contractures of the knee. J Pediatr Orthop. 1984;4(6):700-4.
5. Vulcano E, Markowitz JS, Fragomen AT, Rozbruch SR. Gradual correction of knee flexion contracture using external fixation. J Limb Lengthen Reconstr. 2016;2:102-7.
6. Green WT, Wyatt GM, Anderson M. Orthoroentgenography as a method of measuring the bones of the lower extremities. J Bone Joint Surg Am. 1946;28:60–5.
7. Paley D, Herzenberg JE, Tetsworth K: Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am. 1994;25:425-65.
8. Herzenberg JE, Waanders NA. Calculating rate and duration of distraction for deformity correction with the Ilizarov technique. Orthop Clin North Am. 1991;22:601-11.
9. Paley D. Principles of Deformity Correction. New York: Springer; 2002.
10. Çakmak M, Şen C, Eralp L. Basic techniques for extremity reconstruction. New York: Springer; 2018.
11. Herzenberg JE, Davis JR, Paley D, Bhave A. Mechanical distraction for treatment of severe knee flexion contractures. Clin Orthop Rel Res. 1994;301:80-8.
12. Damsin JP, Ghanem I. Treatment of severe flexion deformity of the knee in children and adolescents using the Ilizarov technique. J Bone Joint Surg. 1996;78(1):140-4.
13. Balci HI, Kocaoglu M, Eralp L, Bilen FE. Knee flexion contracture in haemophilia: treatment with

circular external fixator. Haemophilia. 2014;20(6):879-83.
14. Hosny GA, Fadel M. Managing flexion knee deformity using a circular frame. Clin Orthop Related Res. 2008;466(12):2995-3002.

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