Ilizarov Ring External Fixator: An Experience

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ABSTRACT

Introduction: Ilizarov Ring External Fixator is an "Compression-Distraction Apparatus" to denote its bone lengthening feature whereby two bone ends are compressed together, while at the same time distracting from a corticotomy area. The Ring External Fixator is advantageous in infected non-unions, limb lengthening procedures and correction of angular deformities with good results. The aim of the study was to evaluate indications of different modalities of external ring fixator application by using Ilizarov and Monticelli Spinelli Systems and problems encountered in intra-operative, post-operative and treatment period with analysis of our results.

Method and Materials: The external ring fixator system was used in 50 cases (46 males and 7 females). A total of 12 femora (6 on the right side and six on the left) and 14 tibiae (6 on the right side and 8 on the left) segments operated.

Results: Out of 15 cases, one case showed partial callus formation and another showed the presence of only regenerate bone filling the gap. 13 cases showed good consolidation of bone. One case, which was not included in the table, has very poor callus formation, which needed bone grafting to heal.

Conclusion: Ilizarov ring fixation gives good results. It certainly has a role in the day to day orthopaedic practice especially in case of infected non-union with poor skin condition. Problems involving tibia had better outcome and the patient's compliance was much better than the problems involving femur.

Keywords: Ilizarov Ring, External Fixator

INTRODUCTION

Professor Ilizarov GA has unlocked from within bone a previously hidden capacity to form new osseous tissue under appropriate conditions of distraction and fixation.[1] He pioneered the field of bone and soft tissue regeneration under conditions of tension stress and his technique allows new histogenesis of soft tissue as well as bone. The Ilizarov method of bone lengthening, reconstruction and osteosynthesis has developed vastly since its introduction in the Soviet Union in the 1960s by G.A. Ilizarov and in the Western countries in the early 1980s. Despite the great versatility of its possible applications for bone injuries and diseases, the Ilizarov method could not and cannot be the alternative to a range of other methods that are applied for some specific bone conditions, but rather is a method of choice. Over the ensuing years he discovered the techniques of physical distraction, corticotomy, lengthening, bone transport tissue, regeneration under distraction and many others.[2]

The methods of Ilizarov, including compression; distraction and osteosynthesis offer alternative to the standard treatment of infected non-unions, segmental bone loss and chronic osteomyelitis. Use of the Ilizarov circular frame allows resection of infected bone, repair of the defect and stabilization to consolidation while maintaining or restoring the length of the limb. Joint function is encouraged while the apparatus is worn and functional loading can be initiated with in first few days after application of the frame. The Ilizarov apparatus is very resistant to torsion and bending forces but is adaptable to axial loading. This versatile method is giving simultaneous stabilization and micromotion.[3]

Osteosynthesis with Ilizarov frame is achieved by securing the bone fragment to the external fixator with wires.[4] The present study was undertaken to analyse indications of different modalities of external ring fixator application by using Ilizarov and Monticelli Spinelli Systems and to evaluate various problems encountered in intra-operative, post-operative and treatment period.

MATERIAL AND METHODS

Study was done in Department of Orthopaedics, Kasturba Medical College/Kasturba Hospital, Manipal. The external ring fixator system was used in 26 consecutive cases of 26 patients16 cases were of trauma, 5 cases of infection, one congenital case, 3 neoplastic cases and 1 was iatrogenic case. Ethical clearance was obtained from the institution before the commencement of the study and informed consent was taken from the patients.

All of these 26 cases had undergone multiple procedures previously like wound debridement, skeletal traction, external fixator application, open reduction and internal fixation with plate and screws, intramedullary K'nail, interlocking nailing, bone grafting, posterior bone grafting, gentamicin beads, sequestrectomy and saucerisation, split thickness skin grafting, muscle pedicle flap skin grafting (in non-union cases) and biopsy, radical excisions and spacer plating (tumour cases). Most of the patients selected were complicated cases such as infected non-union, gap non-union, mal-non-union, difficult deformities around the joints with LLD, radical tumour resection with broken spacer plate, operated THR with LLD and others.

History regarding details of original accident and initial or subsequent treatment was taken from patient. The history of infection in the past was also enquired. The nature of residual problem i.e., non-union with or without bone loss, shortening or deformity and pain etc., were enquired. Limb length measurement, movements of adjacent joint and neurovascular status were noted.

Standard antero-posterior and lateral x-rays centred on the deformity were taken from a distance of 1 meter. Grid films were taken in cases associated with limb length discrepancy and bone loss short/segmental. Other radiographic information's include

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type of non-union hypertrophic or atrophic, any sequestrum or quality of interface i.e., pseudarthrosis were noticed. Other investigations like haemogram (CBP), routine urine analysis, pus or discharge from wound for culture and sensitivity and other specific investigations were done prior to surgery.

Ilizarov ring fixator was used in 15 cases, Monticelli Spinelli ring fixator in 9 cases, Modified intramedullary K'nail with Ilizarov ring fixator was used in one case and interlocking nail with Monticelli-Spinelli ring fixator was used in another one case.

A pre-construct of four ring assembly was made for tibia. For femoral construct instead of proximal ring, femoral (Italian) arch with 90° to 120° was used. The rest of the rings construct was the same as tibia; only more soft tissue clearance was required posteriorly for femoral frame than for tibial frame. In a similar manner Monticelli-Spinelli device frame was prepared according to the diameter of limb, with the available 3 ring sizes (small-blue; medium-green and large-grey) and other components. Surgeries were carried under general anaesthesia. Two types of K' wire tips were used, Bayonet tip for diaphyseal region and trocar tip for metaphyseal region. Wire with diameters from 1.5 to 1.8 mm were inserted with a hand drill to avoid heat necrosis, infection and pin loosening.

For tibial frame, proximal transverse wire was passed at tibial tuberosity parallel to knee joint. For femoral frame, a simple conventional table with pillow under buttock was used. The knee was flexed or extended as the wire was passed through quadriceps muscle. The surgical techniques described by Schwartzman and Schwartzman[5]; Paley and Tetsworth[6] were modified and corticotomy was performed.

Postoperative instructions included, elevation of leg on two pillows, broad spectrum antibiotics for 5 days (for infected cases antibiotics were given for at least 3 weeks according to culture and sensitivity) and peripheral circulation and toe movements were evaluated. All patients had weekly or fortnightly clinical and roentgenographic evaluations during the distraction period and, after the end of distraction, the evaluations were done monthly depending upon or desired objectives and patient's co-operation**.** Roentgenographic bone consolidation was classified as, Grade 1 (no regenerate bone in the gap between fragments); Grade 2 (presence of regenerate bone filling the gap); Grade 3 (presence of bone callus bridging less than two thirds of the gap); Grade 4 (presence of bone callus bridging the whole gap) and Grade 5 (neocorticalization).[7] Both antero-posterior and lateral X-rays were taken to know the status of distraction, regenerate and docking or compression at non-union site. Correction or occurrence of deformity was also noted. Pain during the treatment period was rated on a verbal scale with tolerance to the apparatus as follows: Level 1 (slight intermittent pain, or both); Level 2 (moderate and constant pain); Level 3 (severe pain requiring device removal).[7]

Fixators were removd if roentgenographic union was seen at non-union site and corticalisation of regenerate was present and if clinical examination revealed no mobility on removing bars across non-union and rotating the ring; no pain or deformity on removal of tension of wires and allowed patient to walk for one week.

Rehabilitation therapy consisted of plaster of Paris cast with full weight bearing for 6 weeks. After cast removal includes physiotherapy; passive and dynamic orthosis. If any complications like wire tract infection needed incision and drainage were carried out.

RESULTS

There were 23 males and 3 females with an average age of 32 years (in the range of 8 to 66 years) and the majority were between 21-30 years. The cases included 16 post-traumatic non-union and one post infective pathological fracture non-union (13 infected non-union and 13 uninfected non-union). This study includes three post infective (one genu varum, one genu valgum and one tibia vara), one congenital (genu valgum) and one post-traumatic (genu varum) deformities, three neoplastic cases (2 giant cell tumours and 1 osteosarcoma) patients were treated with intercalary bone transportation. A total of 16 patients underwent lower limb lengthening procedure using the technique of distraction transosseous osteogenesis. Thus nine femora and seven tibiae were lengthened. Eight of these infected were non-union cases (both infected and not infected), four deformities with limb length discrepancy, three neoplastic cases (after excision of tumour) and only one with limb length discrepancy.

26 cases were treated on the basis of Ilizarov. Out of them 15 cases were completely treated, whereas 11 cases are still under treatment. These 11 cases are not included in the evaluation of the final results.

Final results were assessed according to the criteria listed in Table-1. The criteria for evaluation of the final results were bone union, osteitis, neurovascular damage, axial deformity, joint stiffness, shortening of the limb, and cosmetic results.[7]

Out of 15 cases, one case showed partial callus formation and another showed the presence of only regenerate bone filling the gap. 13 cases showed good consolidation of bone. One case, which was not included in the table, has very poor callus formation, which needed bone grafting to heal (Table-2).

Of all the 15 patients only one patient showed poor result. This case was intolerant to the ring fixator, where other cases were good. The time required for lengthening varied from each category of case from 80 to 298 days.

The total time took for lengthening and correcting the deformity (Table-3) in cases with limb length discrepancy and deformity was from 80 to 222 (average 144) days. In these cases, duration of ring fixator was varied from 33 to 180 days (average 77 days) and additional protection given by means of cast varied from 42-94 days (average 67 days).

Criteria	Good result	Fair result	Poor result
Bone consolidation	Yes	Yes	No
Osteitis	No	No	Yes
Neurovascular damage	No	No	Yes
Axial deformity	<10°	10 °-20 °	>20°
Joint stiffness			
i. Knee ROM	>80%	75-80%	<75%
ii. Ankle ROM	>75%	50-75%	<50%
Shortening of limb	<3cm	3-5cm	>5cm
Cosmetic results	Cosmetic	No Cosmetic	No Cosmetic
Patient evaluation	Good	Medium	Bad

Table-1: Criteria for evaluation of final results

In the aseptic non-union category (Table-4) the duration of ring fixator time was from 45-140 days (average 92.5 days); additional protection period was for 42-77 days (average 59.5 days) and total treatment period was 122-182 days (average 152 days). Figure-1 shows Varus deformity.

In the infected non-union category, the duration of ring fixator time was from 69 to 214 days (average 141 days), additional protection was obtained 42-90 days (average 54 days) and total treatment period for healing of fracture took 134-298 days (average 193 days) (Table-5).

There were no intraoperative complications. There was no neurovascular injury during transfixation of ring fixator. All the complications occurred in our cases were recorded as per Dror Paley's classification of complications.[8]

Problems appeared in 19 cases, obstacles in six and true complications in seven. The most frequent complications were muscle contractures and joint stiffness in 5 cases, anterior bowing of femur in one case and intolerance to fixator in one case.

Grade		No. of cases	Percentage
I	No regenerate bone in the gap between the fragments	0	0
II	Presence of regenerate bone filling the gap	1	6.7
III	Presence of bone callus bridging <2/3 of the gap	1	6.7
IV	Presence of bone callus bridging the whole gap	0	0
V	Neocorticalization	13	86.6

Table-2: Roentgenographic Bone consolidation:

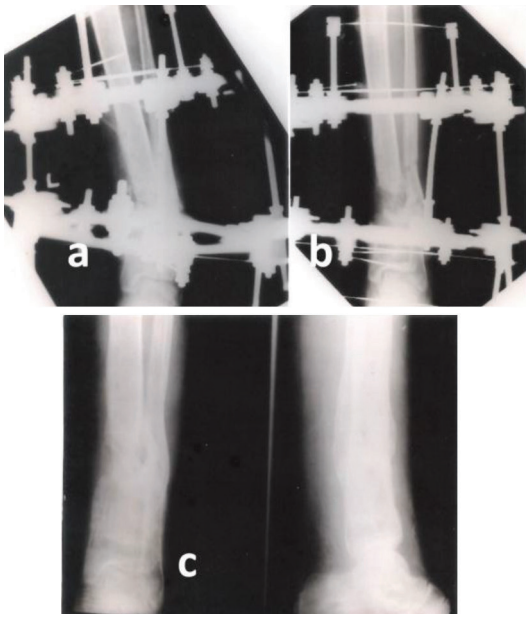

Figure-1: (a) Postoperative check x-ray shows anterior and Varus angulation; (b) Gradual correction of anterior and Varus angulation deformity by distraction compression osteosynthesis; (c) Example of monofocal osteosynthesis showing sound union with gaining 1 cm length,correction of angular deformity within 222 days

Sl. No.	Deformity	Aetiology	Duration of ring fixator (days)	Additional protection (days)	Total treatment period (days)
1.	30° Genu varum/LLD*	Post-op tibia infection	33	73	106
2.	25° Tibia vara/ LLD	COM	34	94	128
3.	20° Genu valgum/LLD	Congenital	38	42	80
4.	28° Genu varum/LLD	Epiphyseal injury	100	84	184
5.	20° Genu valgum/ LLD	Septic arthritis knee	180	42	222
Averages			77	67	144
* LLD = Limb length discrepancy					

Table-3: Time required for deformity and LLD correction

Case No.	Type of non-union	Category	Duration of ring fixator (days)	Additional protection (days)	Total treatment period (days)
1	A-1	Varus deformity (following UTO *)	45	77	122
2	B-3	Hypertrophic non-union	140	42	182
Averages			92.5	59.5	152
* UTO = Upper tibial osteotomy done for osteoarthritis knee.					

Table-4: Time required for union of aseptic nonunions

Case No.	Type of Non-union	Category	Duration of ring fixator (days)	Additional protection (days)	Total treatment period (days)
1	C4	20° varus, 15° anterior angulations	180	42	222
2	C1	Non-union	69	90	159
3	C4	Gap non-union	214	84	298
4	C4	Deformity	130	42	152
5	C4	Gap non-union	92	42	134
6	C4	Gap non-union	200	42	242
7	C4	Non-union	105	42	147
Average			141	54	193

Table-5: Time required for union of infected nonunions

Pin site problems were frequent. 21 cases (80.7%) had Grade 1 pin tract problems, five (19.3%) had Grade 2 problems and none had any Grade 3 problem.

The most frequent problem was transient pin site inflammation. Pin tract infection is usually treated by drainage of pus collection (by taking a niche under local anaesthesia) and a course of antibiotic was given. For two cases pin tract infection needed incision and drainage and in three cases necessitated removal of pin.

DISCUSSION

The method for external fixation introduced by Ilizarov, based on compression-distraction, corticotomy, circular fixation and early weight-bearing, has solved such problems in traumatology and orthopaedic surgery as closed treatment of fractures in the long bones, repair of bone defects without grafts, infected non-union, axial correction, limb lengthening etc.[7,9-12]

The present study aimed to examine the applications of the Ilizarov method for the treatment of infected non-union with poor skin quality and sinuses, complex deformities, radical tumour resected bone defects and for limb length discrepancy.

The results obtained for bone healing (consolidation) in this study using external ring fixator system are very favourable and are quite comparable to that reported by Garcia et al[7] and Schwartzman.[13]

Paley et al[14] treated 7 cases of infected nonunion with shortening but no bone gap using compression and distraction technique. Honsy et al[15] used Ilizarov ring fixator combined with compression and distraction technique to treat infected non-union tibia cases. The theoretical application of Ilizarov principles of internal bone transport may be adaptable through other large pin external fixation systems. However, certain advantages inherent in the Ilizarov frame design are difficult to be reproduced with large pin cantilever external fixation. These include functional weight-bearing properties of the frame during treatment, progressive correction of angulatory and torsional deformities and ability to apply compression, distraction or angulatory correction at multiple levels within a single-frame construct.[16]

We had an experience of three cases of post radical tumour resection with large bone defects managed by bone transportation. This achieved 9 to 12 cm lengthening by distraction osteogenesis with ring fixator supplemented by an intramedullary rodding. These cases are to be studied carefully and the overcoming problems are to be solved. This technique allows one to remove the external fixation earlier and help control the forces through the immature regenerate bone during the consolidation period. Our experience in one case was that the blood loss was greater when a femoral nail was inserted than it was in standard lengthening.[17]

Despite good results and apparent simplicity, the Ilizarov method requires adequate training in using the apparatus and choosing the best place to introduce the wires.[7]

The ability to circumferentially resect infected nonviable cortical bone appears significantly after the requirement for prolonged intravenous antibiotic therapy. The introduction of viable bone fragments under stable conditions through internal bone transport or the compression and stabilization of non-union sites, appear to encourage the natural host mechanisms to eliminate infection.[16]

The main disadvantages of Ilizarov's method are those related to external fixation, including wearing a bulky apparatus for a prolonged period, pin infections, muscle transfixion, loss of joint range of motion, and pain. With proper application of the device, the latter three problems should be minimal. More recently with the use of half pins instead of transfixion wires these problems have been significantly reduced.[18]

We found that the tibial conditions have got excellent acceptability and have no difficulties in treatment. Therefore, tibial conditions will get better results with Ilizarov method when compared to femoral conditions, Ilizarov method is a comprehensive approach to all aspects of chronic tibial non-union that simultaneously addresses deformity, shortening, defects, infection, articular and limb functions, weight bearing, osteoporosis and soft tissue atrophy..

Although the period during which the apparatus is required to be worn may appear as a significant disadvantage, this cannot be shown as a problem clinically. Many of our patients under treatment with external ring fixator were able to do daily activities on par with normal individuals.

The functional load and use of the affected extremity is encouraged during this period, and the majority of patients can return to increased functional activities. Furthermore, disuse osteoporosis, one of the more serious complications occurring in other methods of treatment, may be reduced by the functional treatment offered by the Ilizarov method.[16]

The limitation of this method is the long time duration needed for the newly formed bone tissue to mature, mineralize, and finally consolidate. The external fixator has to be maintained for an extensive period, till the bone consolidation, resulting in surgical, social, and psychological complications.[19]

There is a growing body of knowledge defining the biomechanical environment of the fracture site that is most beneficial to fracture healing. Behrens and Searls have stated that an ideal external fixation frame should be safe, non-obstructive, adaptable to a wide variety of injuries and stiff enough to maintain alignment. That ideal frame should allow full weight bearing and have a low rate of serious complications.[13] In this series it is found that the Ilizarov device meets all of these criteria.

CONCLUSION

In properly indicated cases with difficult orthopaedic problems Ilizarov ring fixation gives good results. It certainly has a role in the day to day orthopaedic practice especially in case of infected non-union with poor skin condition. Problems involving tibia had better outcome and the patient's compliance was much better than the problems involving femur. There was no difference between the Ilizarov and Monticelli/Spinelli System so far as easy application and outcome of the results were taken into consideration.

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