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Research Article

Role of Ilizarov Ring Fixator in Management of High Tibial Diaphyseal Fractures

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Abstract

Introduction: Tibia shaft fractures are the most common long bone fractures. The optimal treatment of high energy tibial fractures remains controversial and a challenging orthopaedic problem that ranges from non-operative to operative or a combination of these techniques depending on soft tissue damage, anatomical location of the fracture, articular surface involvement and bone defects. The role of external fixators is crucial, especially in cases of open fractures, severe soft tissue damage and fracture comminution.

Patients and Methods: Twenty one legs with high energy tibial diaphyseal fractures were treated by Ilizarov external fixator. There were 17 males and 4 females with ages ranged from 19 to 65 years with a mean age of 39 years. Patients classified according to AO classification into 4 type B and 17 type C. The frame was formed of four rings. The aim was to achieve two level of fixation for proximal and distal fragments. Evaluation of the results were done according to the modified method of the association for the study and application of the method of Ilizarov (ASAMI).

Results: Bony results were excellent in 14 cases (Figure 3). Eleven of them were functionally excellent (52.4%) and 3 cases were functionally good (14.3%). Bony results were good in 5 cases, two of them were functionally excellent (9.5%), 2 cases were functionally good (9.5%) and one case functionally fair (4.8%). Bony results were fair in 2 cases which were functionally fair also.

Conclusion: Ilizarov technique is one of valuable tools in managing highly comminuted fracture tibia and it is comparable with other treatment options especially in open fractures with severe soft tissue damage.

Keywords: *Tibia; Fractures; Illizarov; Fixation; Management*

Introduction

Fractures of the tibia are the most common long bone fractures [1]. It commonly affect active patients and are usually occur as a result of high energy trauma that often cause severe soft tissue damage with a high incidence of open fractures [2,3].

Treatment of high energy tibia fractures is challenging problem ranging from conservative to surgical or a combination depending on damage of the soft tissue, location of the fracture, articular surface involvement and bone loss [4,5].

The use of external fixators is of utmost importance, especially in cases of open fractures, severe soft tissue damage and comminuted fractures [6-8]. External fixators help multilevel fracture stabilization with minimal disruption of the soft tissue especially in the treatment of complex high energy fractures [4,9]. The minimal invasion with rigid external fixation provide minimal soft tissue disruption and periosteal stripping will maintain the blood supply of fracture fragments and promote for new callus formation [10,11].

Aim of the Study

The aim of this work is to evaluate the results of using illizarov method in treatment of high energy tibial diaphyseal fractures.

Patients and Methods

In this study, twenty one legs with high energy tibial diaphyseal fractures were treated by Ilizarov external fixator at our institution. The study had been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All patients gave their informed consent prior to their inclusion in the study. Inclusion criteria: Age more than 18 years and less than 70 years, fracture of the tibial diaphysis, recent or within 3 weeks after injury, closed and open fractures. Exclusion criteria: age less than 18 years and more than 70 years, diabetic patients, major neurovascular injury.

There were 17 males and 4 females with male to female ratio 4:1. Patients ages ranged from 19 to 65 years with a mean age of 39 years (Table 1).

Age group	Number	Percentage
0 - < 10	0	0%
10 - < 20	1	4.8%
20 - < 30	4	19%
30 - <40	7	33.3%
40 - < 50	6	28.6%
50 - < 60	2	9.5%
60 - < 70	1	4.8%
Total	21	100%

Table 1: *Age distribution.*

The right side was affected in 14 patients and the left side in 7. Patients classified according to AO classification into 4 type B and 17 type C (Table 2). There were 12 patients with open fractures and 9 patients with closed fractures. The nine closed fractures classified according to Tscherne classification into 5 cases C2 and 4 cases C3. The twelve open fractures classified according to Gustilo Classification into 8 patients type IIIA, 4 cases type IIIB.

AO classification	Number	Percentage
Class A	0	0%
Class B	4	19%
Class C	17	81%
Total	21	100%

Table 2: *AO classification of the patients in the study.*

Surgical procedure:

1. Preoperative assembly of the Ilizarov device: The required frame built in advance, assembling all the parts, then placing the sterilized frame such as a whole over the limb during surgery, and transfixing the rings to the bone with the K-wires.

2. Surgical technique and application of the apparatus: After administration of general or spinal anesthesia, patient was positioned supine on the radiolucent operative table. Then the preassembled frame was introduced through the foot. The frame was formed of four rings, the proximal ring (either complete or 5/8 ring) at the level of fibular head and the distal ring 2 cm distal to the fracture. Two reference wires were inserted, one proximal at the level of center of the fibular head and anterior to it passing through the tibia transversely, and one distally through the tibia and fibula. After the wires were attached to the rings and tension is applied, alignment of the tibial crest was checked and rotation compared to the contralateral foot. After achieving this first reduction (length and rotation), reduction of the fracture can be checked with x-rays. Olive wires placed transversely on the intermediate rings allows for reduction of the fracture on the frontal plane. If in the lateral plane a recurvatum exists, it is possible to move the wires on the intermediate rings until the fragments are aligned. After complete reduction of the fragments, additional stability of the rings was achieved with special clamps.

The aim was to achieve two level of fixation for proximal and distal fragments, each level include at least one wire and one half-pin and the angle between them as close as possible to 90 degrees.

In the case of open fracture, reduction can be performed through the wound, and maintained by applying two wires or screws through the fragments. The frame with the crossed configuration of wires and half-pins was then applied without the need of olive wires. The wires or the screws can be removed at the completion of fixation. It is important to achieve anatomic alignment and not to devitalize the fragments, and to keep the size of incision to a minimum.

Post-operative care

Antibiotics were given for 5 days in closed cases, and for two weeks open cases.

Exercises of the knee and ankle joints started in the first post-operative day as tolerated by the patient and partial weight bearing was allowed with crutches.

Post-operative x-ray was done to confirm the overall alignment.

After two weeks in outpatient clinic x-rays were done and the patient was examined for pin tract infection and other complications then monthly till healing of the fracture then frame removed.

Frame removal

The appropriate time to remove the apparatus depend on the condition of the limb, diagnosis and pathology involved. When the patient is able to walk without pain and x-rays revealed good new bone formation, dynamization of the frame [12] should be done before removal of the frame. After two weeks, if the patient had experienced no discomfort with weight bearing, the apparatus may be safely removed and a protective walking below knee cast was done for one month then patients were followed up every six months.

The external fixation time ranged from 6 to 18 months with a mean of 9 months.

Follow-up

All patients were seen every month to assess the range of motion in the nearby joints, remodeling of the regenerated bone and to detect any late complications.

Evaluation of the results were done according to the modified method of the association for the study and application of the method of Ilizarov (ASAMI) [13], where assessment depend upon bony and functional results (Table 3).

	Bone results	Functional result
Excellent	Bone union, no infection Deformity < 7° LLD < 2.5 cm	Ability to perform previous activities of daily living (ADL). No pain or mild pain. No limp, no soft tissue sympathetic dystrophy Knee or ankle joint contracture Loss of ankle or knee motion <15.
Good	Bone union Failure to meet one of the other criteria	Almost all ADL with minimal difficulty. No pain or mild pain Failure to meet one of the other criteria.
Fair	Bone union Failure to meet two of the other criteria	Most ADL with minimal difficulty No pain or mild pain Failure to meet two of the other criteria.
Poor	Nonunion or refracture Failure to meet three of the other criteria	Significantly limited ADL Significant pain requiring narcotics Failure to meet three of the other criteria.

Table 3: *ASAMI Classification of the results [10].*

Statistical presentation and analysis of the present study was conducted, using the mean, standard error, student t-test, chi-square, and linear correlation coefficient by SPSS V23 by IBM corporation in 2015.

Results

For appropriate assessment and evaluation, results were divided into bony (radiological) results and functional results.

Bony results

Four criteria were evaluated: union, infection, axial deformity < 7°, leg-length discrepancy < 2.5 cm.

An Excellent result was one with union, no infection, deformity of less than 7º and leg-length discrepancy of less than 2.5 cm, good result was one with union with failure to meet one of other criteria, Fair result was one with union with failure to meet two of other criteria, poor result was nonunion or refracture with failure to meet three of other criteria.

Bone union

In this series all the 21 cases achieved union (100%) with mean time of union 6.1 months (about 25 weeks).

Infection

Four cases had infection (19%), 2 cases had osteomyelitis and 2 had cellulitis. Pin tract infection presented in all cases and responded to medical treatment after culture and sensitivity testing.

Deformity

Four cases had residual deformity more than 7º (19%). Two cases had varus (9.5%). Two cases had valgus (9.5%).

Leg-length discrepancy

Five cases had Leg-length discrepancy, 4 less than 2.5 cm and one case of 2.5 cm. All of these cases walk properly with high heel shoes.

According to these criteria for bone results there were, 14 cases were excellent (66.7%), 5 cases were good (23.8%), 2 cases were fair (9.5%) (Figure 1).

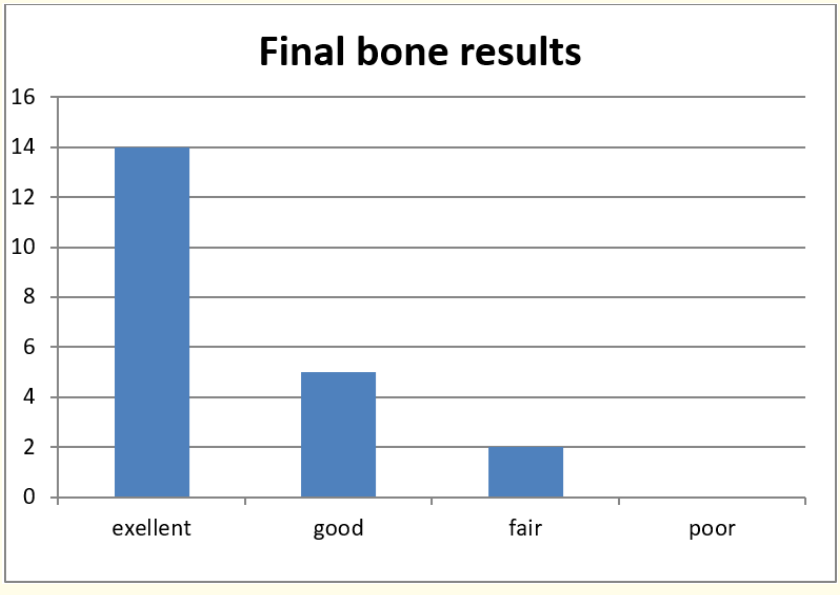

Figure 1: *Final bone results.*

Correlation of bony results with age

In this study, the 21 patients divided into two groups either 30 years or less and more than 30 years.

Six patients were 30 years or less, 5 of them were with excellent results (23%), 1 cases was with good results (4.8%). Fifteen patients were more than 30 years, 9 cases were with excellent results (42.9%), 4 cases with good results (19%) and 2 cases with fair results (9.5%). The difference was found to be statically significant (P = 0.03).

Correlation of bony results with sex

In this study, there were 17 males (81%) and 4 females (19%).

Ten males (47.6%) were with excellent results, 5 were with good results (23%), and 2 were fair results (9.5%). The four females were with excellent results (19%).

There was no significant correlation between sex and functional results. The difference was found to be statically insignificant (P= 1.8).

Correlation of functional results with type of the fracture

According to AO classification cases divided into: Four cases were class B: 2 cases (9.5%) were with excellent results, one case (4.8%) was with good result and one case (4.8%) with fair result. Seventeen cases were class C: 12 cases (57.1%) were with excellent results, 4 case (19%) were with good result and one case (4.8%) with fair result (P = 0.021).

Functional results

The functional results based on:

1. Knee and ankle range of motion.
2. Soft tissue dystrophy.
3. Limping.
4. Pain.
5. Inactivity.

An excellent results met with active patient with no or mild pain, no limp, no soft tissue sympathetic dystrophy, knee or ankle joint contracture < 5° and loss of ankle or knee motion < 15°.

A good results were active patient with minimal difficulty, no pain or mild pain and failure to meet one of the other criteria.

A fair results were active patient with minimal difficulty, no pain or mild pain and failure to meet two of the other criteria.

A poor results were significantly limited activities of daily living, significant pain requiring narcotics and failure to meet three of the other criteria.

Activity

Inactivity means inability to return to daily activities because of the leg injury. In the current study all patients returned to work but four of them returned with limitations (19%).

Range of motion

Five patients had range of motions of ankle joint 50:75% (23.8%), while the range of motions of knee joint were normal in all cases.

Limping

Four patients had limping (19%), because of muscle weakness, leg length discrepancy, and decrease range of motion of ankle joint.

Soft tissue dystrophy

No patients recorded with reflex sympathetic dystrophy.

According to criteria of functional results: 13 cases were excellent (61.9%), 5 cases were good (23.8%) and 3 cases were fair (14.3%).

Relationship of functional results with age

In this study, the 21 patients divided into two groups either 30 years or less and more than 30 years. Six patients were 30 years or less, 4 of them were with excellent results (19%), 2 cases were with good results (9.5%). Fifteen patients were more than 30 years 9 cases

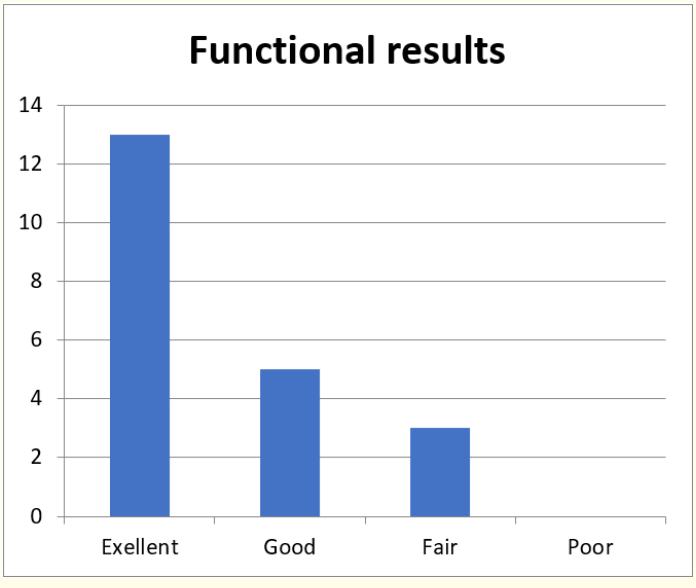

Figure 2: *Functional results.*

were with excellent results (42.9%), 3 cases with good results (14.3%) and 3 cases with fair results (14.3%). The difference was found to be statically significant (P = 0.04).

Relationship of functional results with sex

In this study, there were 17 males (81%) and 4 females (19%). Ten males (47.6%) were with excellent results, 4 were with good results (19%), and 3 were fair results (14.3%). The four females were 3 with excellent results (14.3%) and one with good results (4.8%). There was no significant correlation between sex and functional results. The difference was found to be statically insignificant. (P= 1.53).

Relationship of functional results with time of original trauma

In this study, the patients were divided into two groups either 7 days or less from original trauma or more than 7 days from original trauma.

Cases that operated within 7 days from original trauma were twelve (57.1), ten of them had with excellent results (47.6%) and two with good results (9.5%).

Cases that operated after 7 days from original trauma were nine (42.9%), 2 had excellent results (9.5%), 4 with good results (19%) and 3 with fair results (14.3%). The difference was found to be statically significant (P = 0.05).

Relationship of functional results with site of the fracture

In this study, the patients were divided into 3 groups according to site of the fracture into upper, middle and lower thirds. Fractures of the upper 1/3 of tibial diaphysis were seven all of them with excellent results (33.3%). Fractures of middle 1/3 of tibial diaphysis were six, 3 of them with excellent results (14.3%), 2 with good results (9.5%), and one with fair result (4.8%). Fractures of lower 1/3 of tibial diaphysis were eight, 3 of them with excellent results (14.3%), 3 with good results (14.3%), and 2 with fair result (9.5%). The difference was found to be statically insignificant (P = 2.17).

Relationship of functional results with type of the fracture

In this study, the cases were divided into open and closed cases. Open cases were twelve, 5 were with excellent results (23%), 4 with good results (19%), and 3 with fair results (14.3%). Closed cases were nine, 8 were with excellent results (38.1%) and one with good results (4.8%).

Open cases were classified according to Gustilo classification of open fractures into:

1. Eight patients type were IIIA: 5 cases of them had excellent results (23%) and 3 with good results (14.3%).
2. Four patients were type IIIB: one (4.8%) had good results and 3 with fair results (14.3%).

Closed cases classified according to Tscherne classification of closed fractures into:

1. Five cases were type C2: 4 had with excellent results (19%) and one with good results (4.8%).
2. Four cases C3: all of them with excellent results (19%).

According to AO classification cases divided into:

1. Four cases were class B: 3 cases were B2 (one excellent, one good and one fair) and one case was class B3 with good result.
2. Seventeen cases were class C: one case was C1 (with excellent result), 11 cases were class C2 (8 with excellent results, 2 with good results and 1 with fair result), 5 cases were class C3 (3 with excellent results, 1 with good results and 1 with fair result). The difference was found to be statically significant (P = 0.039).

Relationship of functional results with time to achieve union

In this study, the patients divided into two groups according to time to achieve union into those whom achieved union in less than 7 months and those whom achieved union more than 7 months.

Thirteen cases achieved union before 7 months, 9 cases were with excellent results (42.9%), 3 cases were with good results (14.3%) and one case with fair result (4.8%).

Eight cases achieved union after 7 months, 4 cases were with excellent result (19%), 2 cases were with good results (9.5%) and 2 cases with fair results (9.5%). The difference was found to be statically significant in relation to results in both groups (P = 0.03).

Relationship of functional results with degree of reduction

In this study, the patients divided into two groups according to degree of reduction into those with excellent reduction and good reduction.

Twelve cases with excellent reduction had excellent functional results in eleven cases and good functional result in one case.

Nine cases with good reduction had excellent functional results in two cases, good functional result in four cases and fair functional results in three cases. The difference was found to be statically significant (P = 0.02).

Relationship of functional results with bone results

According to the modified method of the association for the study and application of the method of Ilizarov (ASAMI) [12] results were divided into bony and functional results.

Bony results were excellent in 14 cases (Figure 3). Eleven of them were functionally excellent (52.4%) and 3 cases were functionally good (14.3%).

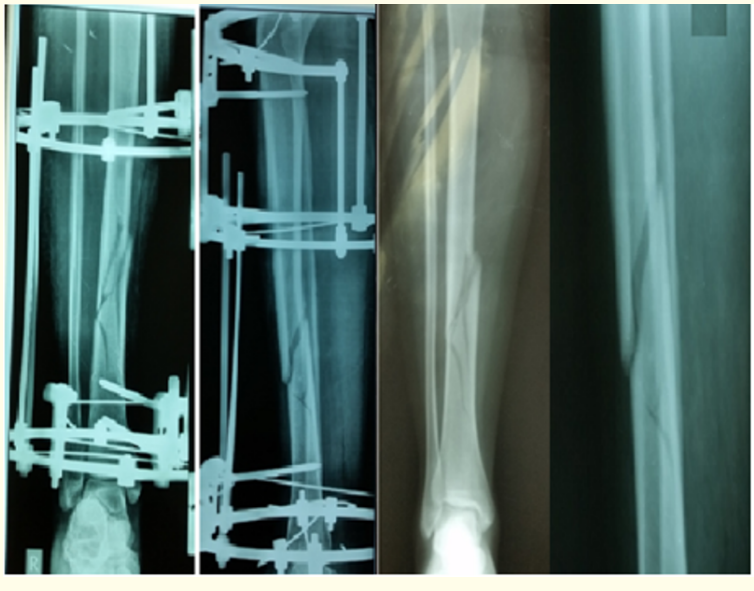

Figure 3: *Female patient aged 30 years old with closed comminuted fracture right tibia. Fracture before and after Ilizarov apparatus application.*

Bony results were good in 5 cases, two of them were functionally excellent (9.5%), 2 cases were functionally good (9.5%) and one case functionally fair (4.8%).

Bony results were fair in 2 cases which were functionally fair also.

The difference was found to be statically significant.

Complications

Almost all cases suffered from some superficial pin-tract infection which responded well to oral antibiotics according to culture and sensitivity tests and proper pin site care.

Two patients had cellulites (9.5%) and responded to oral and intravenous antibiotics.

Two patients had osteomyelitis (9.5%) that required sequestrectomy and debridement.

Four cases had residual deformity more than 7º (19%), 2 cases had varus (9.5%) and 2 case had valgus deformity (9.5%).

Seven patients (33.3%) had range of motion of the ankle joint less than 50% referred treated by physiotherapy.

Leg-length discrepancy present in 5 cases, 4 less than 2.5 cm, and in one case equal 2.5 cm. All cases walk properly with high heel shoes.

Overall, complications presented in ten cases (47.6%) and found to be statistically significant with functional results (P = 0.013).

Figure 4: *Fracture six months later.*

Figure 5: *Fracture after one year.*

Discussion

Tibial shaft fractures are the most common long bone injuries [13]. Their treatment and outcome were determined by the injury mechanism, degree of comminution, displacement and soft tissue damage [14].

The best treatment still remains controversial despite clear goals of treatment [15].

Ilizarov method of fixation is a valuable treatment option through a minimally invasive techniques [16]. Easy application with preservation of blood supply are advantages of the Ilizarov technique [17].

This study included 21 legs with high energy tibial diaphyseal fracture treated by Ilizarov technique. Evaluation of the results were done according to the modified method of the association for the study and application of the method of Ilizarov (ASAMI) [13], where assessment depend upon radiological and functional results.

According to radiological results, fourteen legs (66.7%) had excellent results, five legs (23.8%) had good results, and two legs (9.5%) had fair results. According to functional results thirteen legs (61.9%) had excellent results, five legs (23.8%) had good results and three legs (14.3%) had fair results. All the twenty one legs achieved union (100%) and this is similar to studies done by Hosny [18] and Wani., *et al* [19]. Other series report a union rate of 90% to 92% as those done by Foster., *et al*. [20], Oztu¨rkmen., *et al*. [21] and Giotakis., *et al* [22].

In this study, the mean time to achieve union was 6.1 months (about 25 weeks). Inan., *et al*. [23] reported bone union in 19 weeks in all type IIIA fractures. He also founded that the union time in type IIIB patients without bone loss is not significantly different from that in type II or IIIA.

The longer time of union in this study comparable to other studies mainly due to the type of cases included as most of cases were of type IIIC that need longer time for union. In this study, valgus and varus deformities reported in 4 cases (19%) higher than reported by Anand., *et al*. [24], who reported 8% of the thirty cases included in their study. The higher percent of axial deviation mainly due to smaller sample in this study and type of cases included that were mostly highly comminuted.

In this study, leg length discrepancy reported in 5 cases (23,8%) but all of less than 2.5 cm and no cases more than 2.5 cm while Anand., *et al*. [24] reported leg length discrepancy more than 2.5 cm in 6.7% of cases. The good results in this study may be attributed to that there were no bone loss in all cases.

In this study functional results were excellent (61.9%), good (23.8%) and fair (14.3%). While in the study performed by Hosny [18] he reported excellent results in 93.3% and good in 3.3% and fair in 3.3%, and Wani., *et al*. [19] reported that excellent results were seen in 80.0%, good in 16.7% and fair in 3.3% of cases assessed by ASAMI criteria. The difference between results in this study and other studies related to type of fracture in the study which mostly type IIIC while cases included by Hosny [18] were two grade I, 16 grade II, six grade IIIA, five grade IIIB and one grade IIIC. Wani., *et al*. [19] were included type IIIB fracture 36 patients, type IIIA with 13 patients and type II with 11 patients.

The mean age in this study was 39 years. Excellent results had achieved in 66.7%, good results in 23.8% and fair results in 9.5%. In comparing with work of Hosny [18] mean age was 33.1 and functional results were excellent (93.4%), good (3.3%), and fair (3.3%). Wani., *et al*. [19] reported 32.8 years as a mean age and functional results were excellent (80%), good (16.7%), and fair (3.3%).

In this study**,** according to degree of reduction twelve cases with excellent reduction had excellent functional results in 11 of them (91.7%) and good functional result in one case (8.3%). Nine cases with good reduction had excellent functional results in 2 (22.2%), good functional result in 4 cases (44.5%) and fair functional results in 3 cases (33.3%).

Chandra [25] reported degree of reduction as excellent in 75%, good in 25% of cases with functional results as satisfactory in 68.75% of cases and unsatisfactory rate was 31.25%. Anand., *et al*. [24] reported degree of reduction as excellent in 87% and good in 13%, functional results as excellent in 84%, good in 8%, fair in 8%. Poor and fair results were seen in none of our patients. Nesari., *et al*. [26] reported degree of reduction as 84.2% excellent and 15.8% good, with functional results as 57.89% excellent, 26.31% good, 10.52% fair and 5.26% poor results.

The above showing the role of ideal reduction for achieving the best possible functional results.

In this study, complications were cellulites in 9.5% of cases, osteomyelitis 9.5% of cases, residual deformity more than 7º in 19% of cases and 23.8% of cases had range of motion of the ankle joint less than 50%. No refracture, no malunion or non union.

Hosny [18] reported complications as angular deformity of 7° varus and 10° recurvatum, in 5.9% of cases a limb-length discrepancy of 2 and 5 cm Deep venous thrombosis occurred in 5.9% of patients and eczema was noted in 8.8% of cases.

Chandra [25] reported complications as Pin-tract infection in 25%, Loosening of pin in 12.50%, Ankle stiffness in 6.25%, neurovascular complication in 6.25%, Chronic osteomyelitis in 12.50%, Delayed union in 18.75% of cases.

From all of the above complications varies in different studies according to type of fracture either open or closed, degree of comminution, viability of soft tissues, blood supply and underling diseases. These items that increase rate of infection and affect formation of callus.

Conclusion

In conclusion, Ilizarov technique is one of valuable tools in managing highly comminuted fracture tibia and it is comparable with other treatment options especially in open fractures with severe soft tissue damage.

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