International Journal of Research in Orthopaedics
Kumar H et al. Int J Res Orthop. 2017 Mar;3(2):287-292
http://www.ijoro.org

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20170010

Results of limb reconstruction system in failed osteosynthesis of long bones

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Received: 18 December 2016
Revised: 28 December 2016
Accepted: 31 December 2016

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ABSTRACT

Background: The LRS is an excellent option treating the failed osteosynthesis in long bone fractures, because of failure in healing due to loosening of implant, infection, nonunion, poor bone quality and bone loss associated with deformities, limb length discrepancy, soft tissue problems, functional and financial issues.
Methods: we prospectively treated 30 cases of failed osteosynthesis of long bones (7 plating, 22 nailing & 1 k-wire with plaster) between April 2009 to October 2015 with LRS. Initially we managed by implant removal, freshening of fracture site or radical debridement followed by LRS application.
Results: Union occurred in 93% cases. The eradication of infection was seen in 96.5% cases. Average lengthening done was 4.2 cms. We had 93% excellent and 7 % poor bony result. Functional result was excellent in 45%, good in 48% and failure in 7% cases using ASAMI scoring system.
Conclusions: LRS is an excellent option in the management of failed osteosynthesis especially associated with infection, nonunion, deformities, limb length discrepancy, soft tissue problems, functional and financial issues and also where re-osteosynthesis is challenging with poor bone quality and bone stock. It is simpler technically, patient friendly and short learning curve.

Keywords: Failed osteosynthesis, Long bones fracture, LRS

INTRODUCTION

The high energy trauma is causing much open and complex fracture of long bones in this era. Most of fractures are treated by osteosynthesis. Various forms of osteosynthesis like plates, nails, screws, pins, wires etc. are used to treat most of these fractures. In 5 to 10 % of osteosynthesis may fail due to loosening of implant, infection, nonunion, poor bone quality and bone loss making re-osteosynthesis difficult.[1] In approximately 1% to 10%, depending on various factors, the implanted osteosynthesis may become infected during or after surgery. Infected osteosynthesis is serious complication and requires early and often combined medico-surgical treatments.[2] The difficulties and challenges are infection, nonunion, deformities, limb length discrepancy, soft tissue problems, functional and financial problems.[3,4] So failed osteosynthesis is one of the most challenging orthopaedic situation to manage. External fixation is able to address these problems simultaneously.[5,6] Traditionally complex nonunions are managed by the Ilizarov ring fixators. But, it is cumbersome, heavy and complicated, both for the surgeon and the patient.[7] The limb reconstruction system is uniplanar and less bulky. It has the advantage of allowing distraction and compression at fracture site. It also allows dynamisation of the fracture site which is the essential principle in the treatment of nonunions.[8] The management by implant removal,

freshening of fracture site or radical debridement followed by LRS application.[9]

METHODS

Between April 2009 to October 2015, we prospectively treated 30 cases of failed osteosynthesis of long bones (7 plating, 22 nailing & 1 k-wire with plaster) with LRS at our institute. Among 30 cases, 24 were males with a mean age of 40 years (range 20-65 years) and 6 females with a mean age of 24 years (range 18-30 years). Twenty six cases presented with infected implants. The average shortening was 5.0 cm (1-10 cm).

Initially we managed with implant removal, freshening of fracture site or radical debridement and fixed the nonunion with the LRS in operation theatre under all aseptic condition under suitable anesthesia under facility of an image intensifier. In eight cases polymethyl methacrylate antibiotic cement beads were implanted. Commonly employed antibiotics were aminoglycosides (gentamicin), cephalosporins and vancomycin. Once there were no clinical signs of infection for 6-8 weeks, cement beads were removed. Twenty two cases presented with shortening (1-10 cm). 18 cases underwent corticotomy. Monofocal lengthening was done in 12 cases presenting with shortening ≥2 cm. Bifocal lengthening was done in six cases presenting with shortening ≥7 cm. In cases of humerus, corticotomy and lengthening were not performed. We compressed the fracture site at the rate of 0.25 mm/day for 1-2 weeks and distracted corticotomy site at the rate of 1 mm/day, preferably in four increments a day. LRS was maintained till radiological sign of union was obtained (at least three out of four cortices united).[10]

The limb was protected with POP cast for 3-4 weeks in most of the cases after LRS removal. In our study, bone grafting was not done in any of the cases. Active and passive mobilization of adjacent joint was encouraged the day following operation. Ambulation and partial weight bearing was started on second or third postoperative day depending on patient's compliance, pain, local soft tissue condition and quality of bone. Compression at fracture site was started as early as third day postoperative day. Distraction at corticotomy site was started on the seventh postoperative day. Patients were discharged and asked to follow up regularly (6,12,20 weeks) and at completion of treatment on the OPD basis. Patients were educated about pin tract hygiene, regular dressing, cleaning of external fixator and compression-distraction. At each follow up appointment, problems of pin tract infection, loosening of pins, bolts, clamps were addressed. Check X-ray was taken at each follow up appointment. Once radiological union of fracture site was visualized, at the same time the corticotomy site was assessed and 4 weeks were given for the consolidation. LRS was removed as office procedure in minor operation theatre under intravenous sedation. Average duration of treatment was less for humerus (mean 6 months), compared to femur (mean 9.1 months) and tibia (mean 10.5 months) as shown in Figures 1-4. The details of long bone involvement, previous modalities of treatment, details of treatments and nonunion are summarized as given in Tables 1- 4 respectively. Average duration of the frame was 11.5 months (7-18 months).

Table 1: Long bones involvement.

Type of long bones	Number
Humerus	04
Femur	14
Tibia	12

Table 2: Previous modalities of treatment.

Type of previous osteosynthesis	Humerus	Femur	Tibia	Total
Plating	3	2	2	7
Nailing	1	12	9	22
K-wire	0	0	1	1

Table 3: Details of treatment.

Variable	Number
Mean time of union (months)	9.2 (5-12)
Mean duration of frame (months)	11.5 (7-18)
Mode of treatment	
Compression	6
Compression-distraction	6
Compression+bone transport	18
Follow up in months (average)	30 (12-48)

Table 4: Nonunion variants.

Non-union variants	Number
Septic	26
Aseptic	04

Paired t-test was used to compare the preoperative and postoperative limb length discrepancy and range of movements of joints proximal and distal to the nonunion site. $P < 0.05$ was considered as significant.

RESULTS

The final outcome was calculated in 29 cases for which final follow up was available. Out of 29 cases, we were able to achieve complete union in 27 cases (93 %) and eradication of infection in 96.5% of cases. Two cases failed to unite and one lost to follow up. 18 cases underwent lengthening. Average lengthening achieved was 4.2 cm (range 3-8 cm). Mean residual limb length discrepancy was 1.36 cm. Finally there was no limb length discrepancy in 62% of cases, in 24% of cases it

was 0.1-1 cm and in 14% of cases it was 1.1-2 cm. There was no significant difference in preoperative and post-treatment joint movements (P >0.05). Results were calculated and graded as excellent, good, fair, poor and failure based on ASAMI Scoring System.[11]

Table 5: ASAMI scoring system.

Grading	Bone results	Functional results
Excellent	Union, no infection, deformity < 7 degree; Limb length discrepancy <2.5 cm	Active, no limp, minimum stiffness (loss of <15 degree knee extension/ <15 degree dorsiflexion of ankle), no RSD, insignificant pain
Good	Union+ any two of the following: Absence of infection; deformity <7 degree, Limb length inequality <2.5 cm	Active with one or two of the following Limp, stiffness, RSD, significant pain
Fair	Union+ only one of the following absence of infection, deformity <7 degree, Limb length inequality <2.5 cm	Active with three or all of the following limp, stiffness, RSD, significant pain
Poor	Nonunion/refracture /union+infection+deformity >7 Degree+limb length inequality >2.5cm	Inactive (unemployement or inability to return to daily activities because of injury)
Failures	-	Amputation

Table 6: Our results based on ASAMI scoring system.

Score	Bone results	Functional results
Excellent	27(93%)	13(45%)
Good	-	14(48%)
Fair	-	-
Poor	2(7%)	2(7%)
Failure	-	-

Complications

Complications were classified according to Paley classification as problem, obstacle or true complication. Problem represented difficulties that required no operative intervention to resolve. Obstacles represented difficulties that required an operative intervention. All intraoperative injuries and difficulties during limb lengthening that were not resolved before the end of treatment were considered true complications.

Pin tract infection (n = 24, 83%) was the most common problem, pin loosening (n = 10, 34%) was the most common obstacle and joint stiffness (n = 14, 48%) was most common true complication. Other complications were angulation (n = 4), premature union of corticotomy (n = 1), equinus (n = 8), persistent discharge (n = 2) and refracture (n = 1). In our study at completion of treatment, there was no significant angular deviation (>15 degree) in any case. Twenty five cases (86%) had no angulation, while two cases (7%) had angulation less than 5 degree and in other two cases it was 7 degree. We used ASAMI scoring system as shown in Table 5 to analyse our final results and as shown in Table 6.[11]

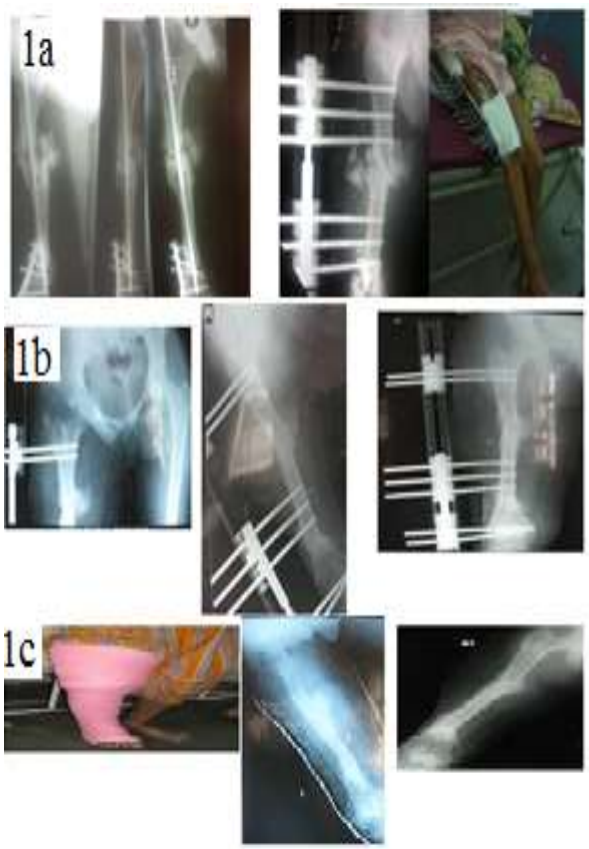

Figure 1a: Pre-op: failed osteosynthesis of right femur with infected nonunion associated with shortening of 10 cm. Postop-immediate postop picture after removal of implant, radical debridement, placement of antibiotic cement beads & LRS fixation for femur. 1b: Bifocal corticotomy of femur done for lengthening with LRS in situ (upper & lower portion of femur) & 8 months follow up-shows the bone regeneration & healing of fracture site of femur with LRS *in situ*. 1c: Removal of LRS & application of plaster after 18 months for femur & another picture shows after removal plaster (after 19 months) & completion of treatment of femur.

Figure 2a: Preop: showing failed osteosynthesis of right tibia with infected nonunion and segmental fibular fracture; Postop & corticotomy: picture shows after implant removal, radical debridement, docking, corticotomy of lower tibia (monofocal) with shortening of 5 cm & LRS in situ. 2b: 1 month postop: this picture shows monofocal lengthening of tibia with LRS in situ; 3 months postop: shows good bone regenerate at corticotomy site, healing at nonunion site of tibia & LRS in situ; 9 months postop: after LRS removal, consolidating of fracture site & bone regenerate of tibia. 2c: Picture shows clinical photograph with shortening of 2 cm and consolidation of nonunion & regenerate of tibia.

Figure 3a: Preop: shows failed osteosynthesis of right tibia with nonunion (k wire & plaster in situ); Postop: shows after removal implant, freshening of fracture site, partial fibulectomy, docking & LRS application for tibia. 3b: 3 months postop: shows uniting fracture of tibia with LRS in situ; 8 months post op & completion of Rx: Shows united tibia fracture after LRS removal.

Figure 4a: Preop: shows failed osteosynthesis (nail) of left humerus with infected non-union; Postop: shows after removal of implant, radical debriement, docking & LRS application of humerus; 4b: 3 months postop: humerus fracture uniting with LRS in situ; 4c: 5 months postop: humerus fracture united with LRS in situ & clinical picture; 4d: Completion of Rx (6 months): picture shows after LRS removal, fracture humerus united & clinical picture.

DISCUSSION

The failed osteosynthesis is one of the most challenging orthopaedic situations to manage. External fixation is able to address these problems simultaneously.[5,6] Traditionally complex nonunions are managed by the Ilizarov ring fixators. But, it is cumbersome, heavy and complicated, both for the surgeon and the patient.[7] The LRS is uniplanar and less bulky. It is easy to construct frame with short learning curve. It also allows dynamisation of the fracture site which is the essential principle in the treatment of nonunions.[8] The management by implant removal, freshening of fracture site or radical debridement followed by LRS application.[9] Limb lengthening can be achieved by bone transport. LRS is mechanically very stable because of the robust construct and variable spread of fixation by the use of sliding clamps. But it is difficult to correct three-dimensional deformities with uniplanar external fixator LRS unlike Ilizarov fixator.

The Intramedullary nailing was the most common mode of previous surgery (73%) followed by plating (23%) and k wire (3%). Fractures united between 5-12 months. The duration of treatment was less in cases of humeral nonunions (mean 6 months), where corticotomy and bone transport was not done. There were no major complications like radial nerve palsy and joint stiffness. Furthermore, the monolateral axial external fixator was tolerated well and allowed movements of shoulder and elbow throughout the period of treatment. It was more in cases with defect nonunions and fracture nonunions at ends of long bones, which needed additional prolonged period for enhancement of union.

In this study the union rate was 93%. Among them, 22.22% was by primary union, 66.67% by bone transport

and 11.11% by callus distraction. It is in contrast study done by Patil et al (86%) and Hashmi et al (90%) and where bone grafting was done to achieve union and compared with others studies as presented in Table 7.[12-15] We were not able to achieve union in two cases (7%). Two cases were infected nonunion of femur. Both cases presented after 5 years with multiple earlier procedures and bone stock was not good. One of them re-fractured after removal of frame, but infection was eradicated. In this case intramedullary nailing was done. In other case, we were neither able to control infection, nor achieve union. This patient refused further treatment. Pin tract infection resolved with regular dressing before removal of frame. Pin loosening was managed by pin reinsertion and intravenous antibiotics. Other obstacles were premature union of corticotomy site in one case (3%) and refracture (3%) in another case. In the case of premature union of corticotomy site, we were not able to achieve normal limb length and there was 2 cm final shortening. Patient was not ready for any other procedure; hence, 2 cm shoe raise was given. While in case of refracture, which occurred in a case of 5-year-old infected nonunion femur, we were able to control infection and after one year of no signs of infection, intramedullary nailing was done. Joint stiffness was mainly pre-existing before applying LRS. We tried to improve it by passive and active exercises including physiotherapy, but there was no satisfactory improvement. The infection appeared to have been eradicated in most of our patients (96.5%). However, since we could not certainly exclude the possible future reactivation of infection, absence of discharging sinus for a minimum of 12 months was considered as success. This rule applied to all our patients. In our patients the outcome of bony consolidation was better than functional results. Excellent bony results of treatment accompanied by resolution of infection do not guarantee a good functional result. The functional result depends primarily on the existing damage of nerves, muscles, vessels, joints and to a lesser extent bones.

Table 7: Comparison of our study with other studies.

Researcher	No of patients	Long bones	Corticotomy	Duration of frame	Result	Conclusions
1. Hashmi MA et al.[13]	107	Tibia-60 Femur-38 Humerus-9	Monofocal-61 Bifocal-49	12.69 months (2.5-64)	90% united, average lengthening- 4.5 cm, 5 amputation	Monolateral external fixation can provide stable fixation for Rx of established non unions.
2. Bassiony A et al.[14]	8	Humerus-8	-	6.5 months	All cases united-100% Elbow ROM full-4 0-90 in 3; 0-60 in1 pin tract inf-4; transient radial nerve palsy-3	Orthofix external fixator without bone graft was successful in the Rx of infected nonunion of humeral shaft.
3. Banks JV et al.[4]	14	femur	Bifocal in all cases	9-13 months	13 cases united (93%), One follow up, 2-5 cm lengthening; no pintract problem	LRS to be a safe and effective techinique to Rx femoral nonunions.
4. Kim NH et al.[15]	101	Tibia-65 Femur-33 Forearm bones-7 Humerus-7	-	8-14 months	Uncomplicated union-69.6%; 24.1% require further Rx	They recommend its use for the primary Rx of open and segmental fractures,& for infected nonunion
5. Our study	30	Tibia-12 Femur-14 Humerus-4	Monofocal-12 Bifocal-6	7-18 months Avg-10.5 months	27 united (93%), average lengthening-4.2 cm; failure to unite-2, lost follow up-1	LRS is excellent option in the management of failed osteosynthesis. It easy to construct frame, less cumbersome to patient and patient friendly.

Active involvement and participation of the patients is necessary for successful LRS treatment. Patient should be involved in daily adjustment of the apparatus. The co-operation of the physical therapist and patient is also important, since the patient must exercise the limb and joints. Nearly all of our patients were able to stand and

walk with partial weight bearing immediately after LRS application. This is considered the most essential part of this method of treatment.

Limitation of our study includes the lack of a control group or a comparison treatment group that does not allow the development of true evidence based guidelines for the optimal treatment of this group of patients. Additionally, our study included more men than women. Female reproductive hormones have been shown to influence the inflammatory response and outcome after trauma.[16,17] Finally, we included patients between 18 to 65 years in our study. The immune system is known to deteriorate with advanced age, rendering older patients less able to mount an appropriate immune response after infection or traumatic challenges.[18-20] Nevertheless, our study represents a large prospective group of patients in which failed osteosynthesis of long bones treated successfully.

CONCLUSION

LRS is an excellent option in the management of failed osteosynthesis especially those associated with infection and shortening. We also conclude that LRS is an excellent option where re-osteosynthesis is challenging with poor bone quality and bone stock. Both surgeon and patient friendly. Easier application and short learning curve.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Kumar H, Honnur SV, Shukla MK, Neruganti SE. Results of limb reconstruction system in failed osteosynthesis of long bones. Int J Res Orthop 2017;3:287-92.