International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2017; 3(1): 33-39

www.orthopaper.com
Received: 08-11-2016
Accepted: 09-12-2016

Hiranya Kumar
Professor, Department of Orthopaedics, Vydehi Institute of Medical Sciences, White Field, Bangalore, Karnataka, India

Siddalingeshwar Vithoba Honnur
Assistant Professor, Department Of Orthopaedics, Vydehi Institute Of Medical Sciences, White Field, Bangalore, Karnataka, India

Manoj Kumar Shukla
Assistant Professor, Department Of Orthopaedics, Vydehi Institute Of Medical Sciences, White Field, Bangalore, Karnataka, India

Correspondence
Siddalingeshwar Vithoba Honnur
Assistant Professor, Department of Orthopaedics, Vydehi Institute of Medical Sciences, Whitefield, Bangalore, Karnataka, India

Functional outcome of management of infected non-union of humerus by limb reconstruction system (LRS)

Hiranya Kumar, Siddalingeshwar Vithoba Honnur and Manoj Kumar Shukla

DOI: http://dx.doi.org/10.22271/ortho.2017.v3.i1a.08

Abstract
Introduction: The infected non-union of humerus resulting from surgical intervention to achieve bone healing are very difficult to manage by traditional methods.
Materials & methods: We treated 20 infected non-union of diaphyseal fracture of humerus by LRS between 2009-15. All had prior surgical management, infected nonunion followed plating in 14 cases, 1 nailing case & 5 cases of external fixator. All patients had pain, atleast one sinus discharging pus and severe functional impairement of affected arm. There are 15 men and 5 women with a mean age of 39.7 years (range23-60yrs).
Results: Bone healing achieved in 19 cases (95%). The eradication of infection was achieved in all cases. The mean time of union was 3.5 months (range 2-8 months). Good functional improvement was present. There were no major pin tract problems requiring removal of Schanz pins. 1 developed radial nerve palsy who recovered spotaneously. No patient required bone grafting and corticotomy procedure.
Conclusion: The LRS alternative to the ring fixator in the treatment of infected non-union of humeral shaft, because of good patient compliance, decreased surgical learning curve, shortened duration of hospitalisation and immobilisation with good functional recovery.

Keywords: Infected non-union, humerus, LRS

1. Introduction
The incidence of non-union after operative treatment of humeral diaphyseal fracture has been reported to range between 2.5% to 13% [1-4]. The failure of fixation results from various factors like personality of fracture, poor patient compliance, osteoporosis, surgical techniques and infection. The hallmark of infected non-union consists of nonviable tissue, sequestrum and sinus discharge. Local ischaemia renders non-union more vulnerable to superimposed infection and resistant to systemic antibiotics. The infection hampers bone healing, loosening of implant, causes soft tissue atrophy, joint stiffness and leading disuse osteoporosis. The infection and non-union at the fracture site complicates further management. In that scenario, option of managing the problem by external fixator either by illizarov or LRS. But enthusiasm for illizarov techinique has been tempered by its complexity and technical diffculty, the commitment of time and resources required for a good result and potential numerous complication [5, 6].
We have used the limb reconstruction system (LRS) to stimulate union by stabilisation and compression after radical excision of infected bone. We report the results of 20 patients with infected non-union of humeral shaft that were managed at our hospital using limb reconstruction system.

2. Materials & methods
20 consecutive patients with infected non-union of humerus shaft treated at our hospital between 2009-15. The 20 patient consist of 15 men and 5 women with mean age of 39.7 years (range 23-60 years). The infected non-union middle third 8 patients and distal third in 12 patients. The patient undergone average of 1.7 previous surgical procedure (range 1-4). These injuries from road traffic accidents in 15 patients and from fall in 5 patients. The initial treatment was operative in all cases. The initial fracture was open in 5 cases and closed in 15 cases.

The 14 cases closed were infected after plate fixation and 1 case was closed was infected after nailing. The mean period between the initial treatment and application of LRS was 13.6months (range 3-36 months). The infective organism were MRSA 2, pseudomonas 3, staphylococcus in 10, in 5 cases no organism could be detected (Table 1).

The surgery was one stage procedure that involved exploration of radial nerve, removal of previously implanted implant, obtaining deep culture, a thorough debridement and sequestrectomy of the non-union site to expose fresh bleeding from bone ends, application of LRS with immediate bone to bone contact at non-union site. Surgical exposure in all cases was performed through the previous incision. Following debridement, none of the resulting segmental defects were larger than 3.0 cm, and shortening was acceptable in all cases. The LRS fixator was fixed to the humeral diaphysis using 5 mm diameter half pins (3 or 2) proximally and distally (3 or 2) except in one case proximal segment of bone fixed with 6 pins as the fracture was distal third region. Postoperatively, all patients were administered 6 weeks of appropriate antibiotics (2weeks of IV antibiotics and 4 weeks of oral antibiotics). The LRS fixator was used to apply monofocal (Table 2) compression at an initial rate of 0.25 mm per day. Patients and their families were instructed in pin care, cleaning and hygiene. Each pin site was cleaned daily with normal saline solution. The pin sites were covered with sterile dressings, which were changed after pin cleaning. The pin sites were inspected at each hospital visit, and patients were instructed to call immediately if swelling, erythema, purulent discharge, or severe pain were noted at any pin site. Postoperative rehabilitation included active and active-assisted range of motion beginning on the first postoperative morning. Passive range-of-motion exercises and joint mobilisation of the elbow were incorporated into the rehabilitation programme as tolerated, usually within the first 2 weeks following surgery. Physical therapy modalities were used to manage symptoms. Gradual strengthening exercises for the hand, wrist, elbow and shoulder were added during the outpatient rehabilitation and during the compression and consolidation phases of treatment. All patients attended regular therapy sessions, usually 2 to 3 times a week, and were instructed to perform a home exercise programme twice a day. Patients returned to the clinic every 1 to 2 weeks for monitoring of compression rate and bone healing in the first postoperative month and then every 2 to 4 weeks until bone union was achieved. The LRS fixator was removed when there was evidence of bony union seen on 3 of 4 cortices, as described by Heckman and colleagues [7]. Two patients (case 2 and case 5) had delayed radiological signs of union for more than 6 months. We applied 'callus massage'5 at the sites of the fracture, alternating short periods of progressive distraction with periods of compression (0.5 mm of distraction a day for 7 days, followed by 1 mm of compression a day for 7 days, over a 4-week period). The result was net compression with slight shortening. Our primary objective was bone union accepting the resultant shortening [8].

Table 1: Patient Characterstics at presentation and type of infecting organism.

case	Age(years)	Gender	Time of nonunion	Aetiology	Previous treatment	Type of fracture	Localisation	Type of organism
1	28	M	6	RTA	2	CLOSED	MIDDLE1/3	Mrsa
2	23	M	9	RTA	1	CLOSED	MIDDLE1/3	S. Aureus
3	35	M	4	RTA	1	CLOSED	DISTAL 1/3	S. Aureus
4	37	M	36	RTA	4	OPEN	DISTAL 1/3	No Growth
5	41	F	3	RTA	1	CLOSED	DISTAL1/3	Mrsa
6	45	M	12	FALL	2	CLOSED	DISTAL1/3	Pseudomonas
7	49	M	5	RTA	1	CLOSED	MIDDLE1/3	No Growth
8	50	F	24	FALL	3	OPEN	DISTAL1/3	No Growth
9	31	M	7	RTA	1	CLOSED	DISTAL1/3	S. Aureus
10	39	M	11	RTA	2	OPEN	MIDDLE1/3	S. Aureus
11	32	M	14	RTA	1	CLOSED	DISTAL1/3	Pseudomonas
12	44	M	8	RTA	1	CLOSED	DISTAL1/3	No Growth
13	57	F	10	FALL	1	CLOSED	DISTAL1/3	No Growth
14	60	F	16	RTA	2	CLOSED	MIDDLE1/3	S. Aureus
15	26	M	19	RTA	1	OPEN	DISTAL1/3	S. Aureus
16	29	M	22	FALL	4	CLOSED	DISTAL1/3	Pseudomonas
17	33	M	13	FALL	1	CLOSED	MIDDLE1/3	S. Aureus
18	38	M	15	RTA	3	OPEN	DISTAL1/3	S. Aureus
19	40	F	21	RTA	2	CLOSED	MIDDLE1/3	S. Aureus
20	54	M	17	RTA	1	CLOSED	MIDDLE1/3	S. Aureus

MRSA: Methicillin-resistant Staphylococcus aureus; RTA: road traffic accident; S. aureus: Staphylococcus aureus

Table 2: details of treatment

Variable	number
Mean time of union(months)	3.5(2-8)
Mean time removal of frame(months)	5.5(4-10)
Mode of treatment	
Compression	18
Compression-distraction	2
Follow up in months (mean)	23(12-40)

Table 3: Functional scoring (kurgan 1974) [9].

Variable	shoulder & elbow ROM	strength at elbow& shoulder	pain number
Excellent abduction>150^0, <10^0 loss of movement In any direction	normal	nil	10
Good abduction>120^0 <15^0 loss of movement In any direction	normal	nil	9
Fair abduction:90-120^0 <20^0 loss of movement In any direction	less than normal	mild	0
Poor abduction<90^0 >20^0 loss of movement In any direction	grossly less	more	1

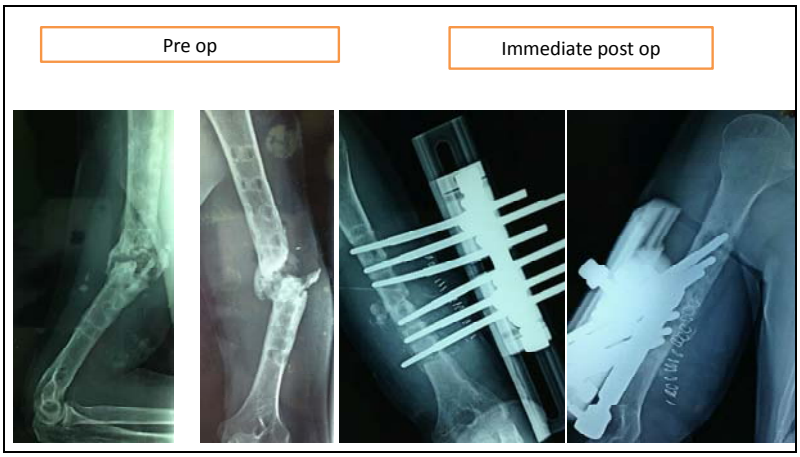

Fig 1A

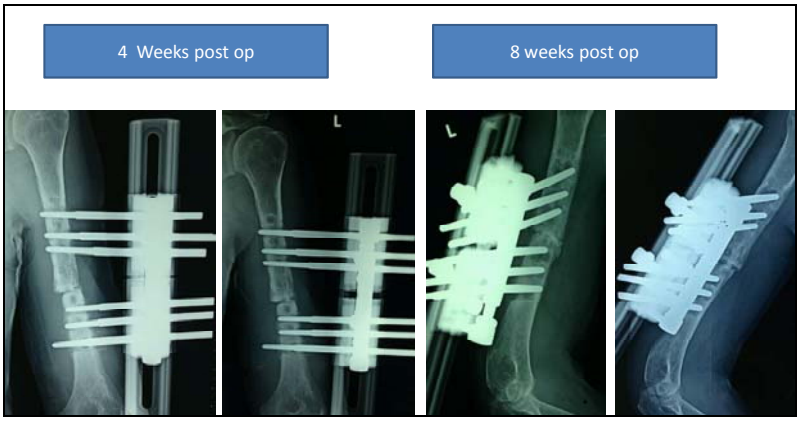

Fig 1B

Fig 1C

Fig 1D

Fig 1 A-D: Patient operated for diaphyseal fracture with plating, presented with infected non-union, underwent implant removal, radical debridement & LRS

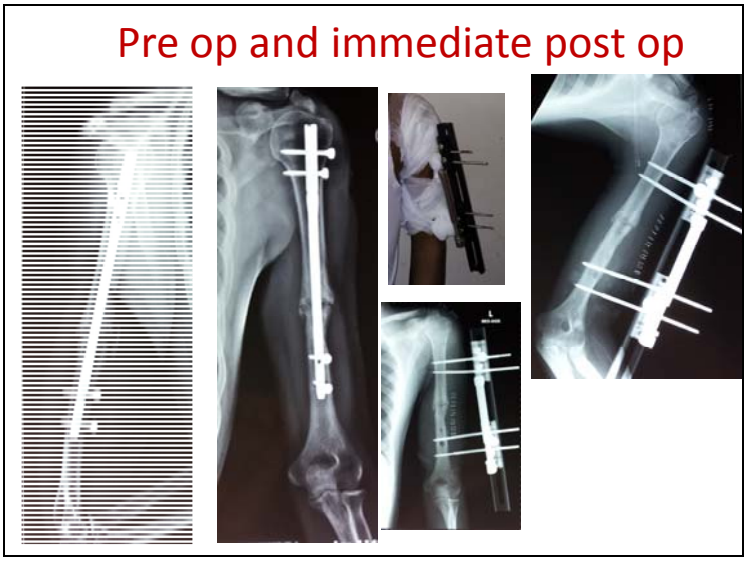

Fig 2A

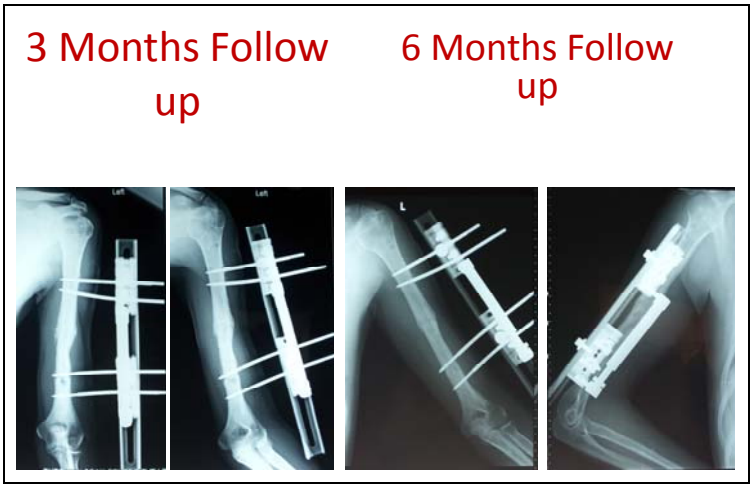

Fig 2B

Fig 2C

Fig 2 A-C: Patient operated with closed nailing for diaphyseal humerus fracture, presented with infected non-union of humerus with nail in situ, underwent implant removal, radical debridement & LRS

Fig 3A

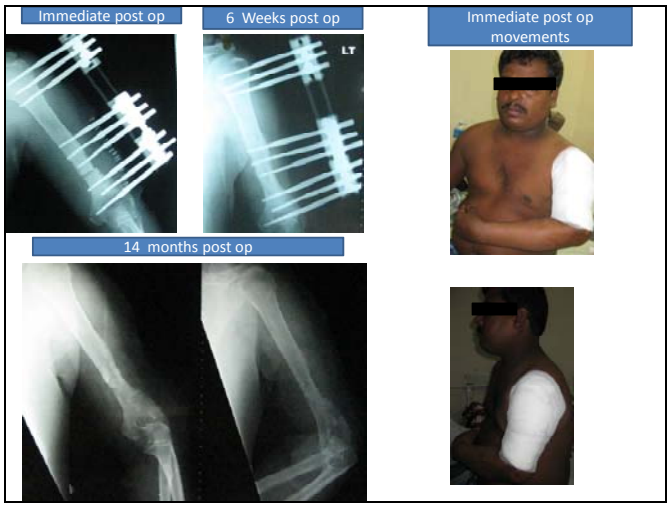

Fig 3B

Fig 3 A-B: Patient operated with spanning AO external fixator for open diaphyseal humerus fracture, presented with infected non union, underwent implant removal, radical debridement & LRS

3. Results

Union was achieved in 19 (95%) of 20 patients and infection was arrested in all patients. All wounds healed primarily. The mean time to union was 3.5 months (range, 2 to 8) after application of the frame and the mean time to removal of the frame was 5.5 months (range, 4 to 10) (Table 2). Cure of disease was defined as no recurrence of infection or sinus discharge at the latest follow-up ranging from 12 to 40 months. 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. The final functional result [9]. Was graded as excellent when there was shoulder abduction>150^0, No loss of >10^0 of movement in any direction, full strength at elbow and shoulder joints and absence of pain at the non-union site and adjacent joints. It was graded as good when there was shoulder abduction>120^0, No loss of >15^0 of movement in any direction, full strength at elbow and shoulder joints and absence of pain at the non-union site and adjacent joints. A fair result was shoulder abduction 90-120^0, No loss of >20^0 of movement in any direction, less than full strength at elbow and with mild manageable pain. Shoulder abduction <90^0, loss of motion>20^0, gross decrease in power in shoulder and elbow with pain hampering activities of daily living was considered a poor result. 19 (nineteen) of 20 patients reported that they were satisfied with the outcome of the revision non-union surgery (excellent & good functional outcome) (Figure1A-D, Figure2A-C & Figure 3A-B). One patient was dissatisfied (poor outcome) (Table 3). His initial humerus fracture resulted from a polytrauma motor vehicle accident in which he sustained a closed head injury and multiple other long bone injuries (case 4).

4. Complications

The application of the LRS fixator resulted in nerve injuries in 3 patients. The median and the lateral antebrachial cutaneous nerve were involved in 2 cases (case 2 and 4) but there was full recovery within a week of operation. The third (case 6) suffered an intraoperative palsy of the radial nerve. During the operation, the surgeon noticed twitching in the extensors of the wrist during retraction of the nerve. The patient had a wrist drop immediately after the operation, but regained MRC grade-5 strength in the extensors 3 months later. Pin-track infection occurred in 4 patients. With local skin care and treatment with oral antibiotics, this resolved in all except 1 patient whose pin tracks required incision and drainage. No patient developed chronic deep infection. Puckering of the skin around the pins caused discomfort in 2 patients. It was relieved by incising the skin around the site of the pin under local anaesthesia.

5. Discussion

The purpose of our study was specifically to assess the effectiveness of using the LRS fixator in treating infected non-union since such cases are notoriously difficult to treat.[10-12] Further surgery can put vital structures such as the radial nerve at risk. Internal fixation in the presence of infection would be contraindicated and can be difficult because of osteopenia and bone defects. Satisfactory results with the illizarov method of treating non-union of fractures of the humerus had been previously reported [13-16]. However, the iIlizarov technique has been tempered by its complexity and technical difficulty, the commitment of time and resources required for a good result and the potential for numerous complications.[5-6] The hallmark of infected non-union consists of non-viable tissue, sequestrum and sinus discharge. Local ischaemia renders non-union more vulnerable to superimposed infection and resistant to systemic antibiotics. We designed one-stage treatment protocol to terminate the vicious cycle. First we eliminated the infection, followed by osseous reconstruction. Infected non-union in the humerus compromises upper limb function. The ultimate goal of treatment is to eradicate the infection and prevent recurrence. It is diffcult because of (1) inadequate exteriorisation at the site of infection, and thus inadequate removal of necrotic and infected tissue, (2) failure to eradicate infection and (3) recurrence attributable to failure to fill the resulting bone defect. To eradicate the infection, the first step is to remove the implant, do radical debridement, sequestrectomy and removal of infected bone ends. The remaining bone should have visible evidence viability with punctate bleeding. In this series, all the debridements were extensive, with no attempt to preserve the diseased bone or soft tissue. Radical debridement, however, created bone gap ranging from 1 to 3 cm (average, 2 cm) which was closed by compression. It was possible to achieve stable fixation with the LRS fixator. As the pins can be placed away from the site of the fracture, the frame can be applied after excision of the infected non-union. Union was achieved without bone grafting and corticotomy in 19 cases. A further advantage of the method is that it allows both compression and distraction, which stimulate healing [17, 18] In our series, 19 cases united with the application of the LRS fixator which achieved both compression and maintaining the alignment of the fracture, while eliminating shear forces. Our clinical outcomes with the LRS fixator in infected cases are comparable to those of open reduction and internal fixation (ORIF) in non-infected cases. The rate of bone union following ORIF in the treatment of non-infected distal humeral non-unions has been reported to range from 64% to 100% [19, 21]. Our results are contrary to those of Ring and colleagues [22]. Who reported on 5 patients with infected distal humerus fractures treated with static compression using a thin-wire external fixator; 1 patient had also received a vascularised fibular bone graft [22]. Four of the 5 patients in their series required a second operative procedure (ORIF, bone graft, or both) to achieve bone union; the fifth patient did not achieve bone union and refused further operative intervention. Among 20 patients 19 patients in our series achieved bone union after treatment with the LRS fixator acute compression technique. The amount of shortening following treatment in our patients was less than 3.0 cm in all cases (average, 2 cm). Acute shortening of the upper extremity of 3 to 4 cm is generally well tolerated.[23-24] Osseous and soft-tissue infection is a challenge to the surgeon and is rather intractable, especially in combination with instability. In our series, there was a month-to-year delay in treatment. Prolonged immobilisations and tissue scarring may further compromise the residual, if any, joint function. Aggressive management and early rehabilitation should be started as soon as possible. The one-stage protocol is recommended for the treatment of infected humeral non-union because it shortens the duration of hospitalisation and immobilisation. Physical therapy thus starts earlier. The functional result is encouraging.

6. Conclusion

The LRS is a uniplanar dynamised external fixator that is light weight, easy to construct frame with short learning curve and based on same basic principle of illizarov. So LRS is a alternative to the ring fixator in treatment of infected non-union of humeral shaft, because it shortened duration of hospitalisation and immobilisation with good functional recovery.

7. References

1. Foster R, Dixon G, Bach A, Appleyard R, Green T. Internal fixation of fractures and nonunions of the humeral shaft. J Bone Joint Surg Am. 1985; 67(A):857-65.
2. Foulk D, Szabo R. Diaphyseal humerus fractures: natural history and occurrence of nonunion. Orthopaedics 1995; 18:333-5.
3. Healy W, White G, Mick C, Brooker A, Weiland A. Nonunion of the humeral shaft. Clin Orthop Relat Res 1987; 219:206-13.
4. Rosen H. The treatment of nonunions and pseudoarthroses of the humeral shaft. Orthop Clin North Am 1990; 21:725-42.
5. Ilizarov G. Transosseous Osteosynthesis: Theoretical and Clinical Aspects of the Regeneration and Growth of Tissue. New York: Springer Verlag, 1992.
6. Paley D. Problems, obstacles and complications of limb lengthening by the Ilizarov technique. Clin Orthop Relat Res 1990; 250:81-104.
7. Heckman J, Ryaby J, McCabe J, Frey J, Kilcoyne R. Acceleration of tibial fracture healing by non-invasive, low-intensity pulsed ultrasound. J Bone Joint Surg Am. 1994; 76:26-34.
8. Raschke M, Khodadadyan C, Maitino P, Hoffmann R, Sudkamp N. Nonunion of the humerus following intramedullary nailing treated by Ilizarov hybrid fixation. J Orthop Trauma. 1998; 12:138-41.
9. Ilizarov GA, Shevtsov VI. Osteosynthesis of compression - distraction in the treatment of non-union of the humerus. Kurgan, 1974.
10. McKee M, Miranda M, Riemer B, Blacier R, Redmond B, Sim S *et al*. Management of humeral nonunion after failure of locking intramedullary nails. J Orthop Trauma. 1996; 10:492-9.
11. Ranieri L, Olmi R. Nonunion of the humerus after internal fixation: treatment by intramedullary nailing and grafting. Ital J Orthop Traumatol 1976; 2:51-5.
12. Matsen FIII, Smith K. Effectiveness evaluation and the shoulder. In: Rockwood CA, Matsen FA III, editors. The Shoulder. 2nd ed. Philadelphia: WB Saunders, 1998, 1313-39.
13. Catagni M, Guerreschi F, Probe R. Treatment of humeral nonunions with the Ilizarov technique. Bull Hosp Jt Dis Orthop Inst 1991; 51:74-83.
14. Lammens J, Bauduin G, Driesen R, Moens P, Stuyck J, Desmet L *et al*. Treatment of nonunion of the humerus using the Ilizarov external fixator. Clin Orthop 1998; 353:223-30.
15. Cattaneo R, Catagni M, Guerreschi F. Applications of the Ilizarov method in the humerus: lengthenings and nonunions. Hand Clin 1993; 9:729-39.
16. Cuiccarelli C, Cervellati C, Montanari G, Masetti G, Galli G, Carpanelli F. The Ilizarov method for the treatment of nonunion in the humerus. Chir Organi Mov 1990; 75:115-20.
17. ASAMI group. Nonunions of the humerus. In: Bianchi Maiocchi A, Aronson J, editors. Operative Principles of Ilizarov: Fracture Treatment – Nonunion Osteomyelitis-Lengthening Deformity Correction. Baltimore etc: Williams and Wilkins, 1991, 263-72.
18. Saleh M, Royston S. Management of nonunion of fractures by distraction with correction of angulation and shortening. J Bone Joint Surg Br. 1996; 78-B:105-9.
19. Ackerman G, Jupiter J. Non-union of fractures of the distal end of the humerus. J Bone Joint Surg Am. 1988; 70:75-83.
20. Sanders A, Sackett J. Open reduction and internal fixation of delayed union and nonunion of the distal humerus. J Orthop Trauma. 1990; 4:254-9.
21. Brauer C, Rosen A, Olchanski N, Neumann J. Cost-utility analyses in orthopaedic surgery. J Bone Joint Surg Am 2005; 87:1253-9.
22. Ring D, Jupiter J, Toh S. Salvage of contaminated fractures of the distal humerus with thin wire external fixation. Clin Orthop Relat Res 1999; 359:203-8.
23. Brinker M. Nonunions: evaluation and treatment. In: Browner BD, Levine AM, Jupiter JB, *et al*, editors. Skeletal Trauma: Basic Science, Management, and Reconstruction. Philadelphia: WB Saunders, 2003, 507-604.
24. Pugh D, McKee M. Advances in the management of humeral nonunion. J Am Acad Orthop Surg. 2003; 11:48-59.