Management of infected total knee arthroplasty by Ilizarov fixator

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Introduction
Persistent infection after total knee arthroplasty (TKA) is a very serious complication. Arthrodesis is considered if the prosthesis cannot be retained or revision surgery is obviated. The purpose of this study was to evaluate the radiological and functional results of knee arthrodesis with Ilizarov external fixator to treat infected TKA.
Patients and methods
This was a retrospective study of 13 patients with infected TKA treated by implant removal, debridement, and fusion by Ilizarov fixator operated from October 2010 to March 2015. The study included nine females and four males with a mean age of patients of 64.08 years. Seven patients were diabetics and two had a past history of deep venous thrombosis. Time, from the primary TKA till knee fusion, ranged from 18 to 37 months. All patients had previous surgical interventions with a mean of 4.62 procedures. Eleven patients had draining sinuses. In addition to clinical and radiographic evaluation, the functional assessment was done by Western Ontario and McMaster Universities Osteoarthritis index questionnaire.
Results
Patients were followed up for a mean of 28.62 months. The mean external fixator period was 7.77 months. Postoperative hematoma occurred in one patient. Pin track infection occurred in 10 cases. All cases had successful fusion except two patients and infection was controlled in all cases. The mean leg length discrepancy was 3.96 cm. The mean postoperative Western Ontario and McMaster Universities Osteoarthritis index score was 30.08.
Conclusion
Knee arthrodesis by Ilizarov external fixator for treating persistently infected TKA achieved high fusion and infection control rates and provided a stable limb with pain relief and functional improvement.

Keywords:
arthrodesis, external fixator, failed knee arthroplasty, Ilizarov, infected knee

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Introduction

The incidence of total knee arthroplasty (TKA) has increased tremendously over the last few decades. Hence, there is an increasing number of postoperative complications including septic implant failures [1]. Periprosthetic joint infection is one of the most challenging and devastating complications often associated with prolonged treatment and recurrent surgical interventions [2–4]. The incidence of infection in TKA varies from 0.5 to 15% [5].With severe and persistent infection of the replaced knee joint, further revision is contraindicated. The treatment options may be reduced to either arthrodesis or above-knee amputation. Of these, arthrodesis of the knee joint is generally considered the preferred management [1,4]. Although arthrodesis may not be the satisfactory end goal for the patient, it can be a successful salvage procedure providing a stable limb for ambulation with very significant pain relief. Arthrodesis of failed septic TKA is challenged by uncontrolled infection, instability, repeated operations, soft tissue problems, and bone loss that are jeopardizing to bone healing [1,5].

Variable surgical techniques are reported for knee arthrodesis, each with its own pros and cons [4–6]. External fixation is mostly considered when using an intramedullary nail (IMN) or plate fixation is contraindicated, as in the presence of active infection [1,7]. The Ilizarov ring fixator offers several advantages that makes it an ideal fixation tool in such complicated cases [8].

The purpose of this study was to investigate the success of a single-stage knee arthrodesis with Ilizarov external

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fixator, to assess the infection control rate and to evaluate the functional outcomes and satisfaction of patients who underwent a last-resort after failed infected TKA.

Patients and methods

This retrospective study was approved by the Research Ethics Committee of the University. The inclusion criteria of the study included: (a) adult patients with a persistent, deep periprosthetic infection of a TKA who are not a candidate for two-stage revision arthroplasty, (b) treatment by single-stage knee arthrodesis using the Ilizarov external fixator, and(c) a follow-up period of at least 18 months. The exclusion criteria included patients who underwent knee arthrodesis for other indications, such as septic knee arthritis and arthrofibrosis and the patients who lost follow-up. The study included 13 patients with infected TKA operated for arthrodesis from October 2010 to March 2015. Diagnosis of deep, chronic periprosthetic infections was done on the basis of elevated erythrocyte sedimentation rate/C-reactive protein levels and clinical findings including discharging sinuses. Patient demographics are summarized in Table 1.

The study group comprised four males and nine females, with a mean age of 64.08 years (range, 55–79 years; SD, 7.41 years) at the time of arthrodesis. Arthrodesis was done for the right knee in seven patients and for the left knee in six patients. Seven patients were diabetics and four were heavy smokers. Two patients had a past history of deep venous thrombosis (DVT). The indications for primary arthroplasty had been osteoarthritis in 11 patients and rheumatoid arthritis in two. Time, from the primary TKA knee till fusion, ranged from 18 to 37 months with a mean of 23.62 months (SD, 5.82 months). All patients had previous surgical interventions with a mean of 4.62 (SD, 1.04; range, 3–6) procedures including the primary TKA. Repeated debridement was done in all cases with a range of 2–4. Eight patients had removal of the prosthetic components with the application of antibiotic bone cement spacer for the possibility of revision TKA (Fig. 1). None had previous attempts at arthrodesis.

General patient assessment was done including evaluation by an anesthesiologist, cardiology evaluation, and chest radiograph. Thorough clinical and radiographic evaluation was carried for a full assessment of the condition. All patients were nonweight bearing on the affected side and mostly move with a wheelchair. Eleven patients showed draining sinuses and two were quiescent with dry scars. One patient had associated dislocation of the components (Fig. 2). Doppler ultrasound examination was negative for DVT in 11 cases and showed recanalization in those two who had a history of DVT.

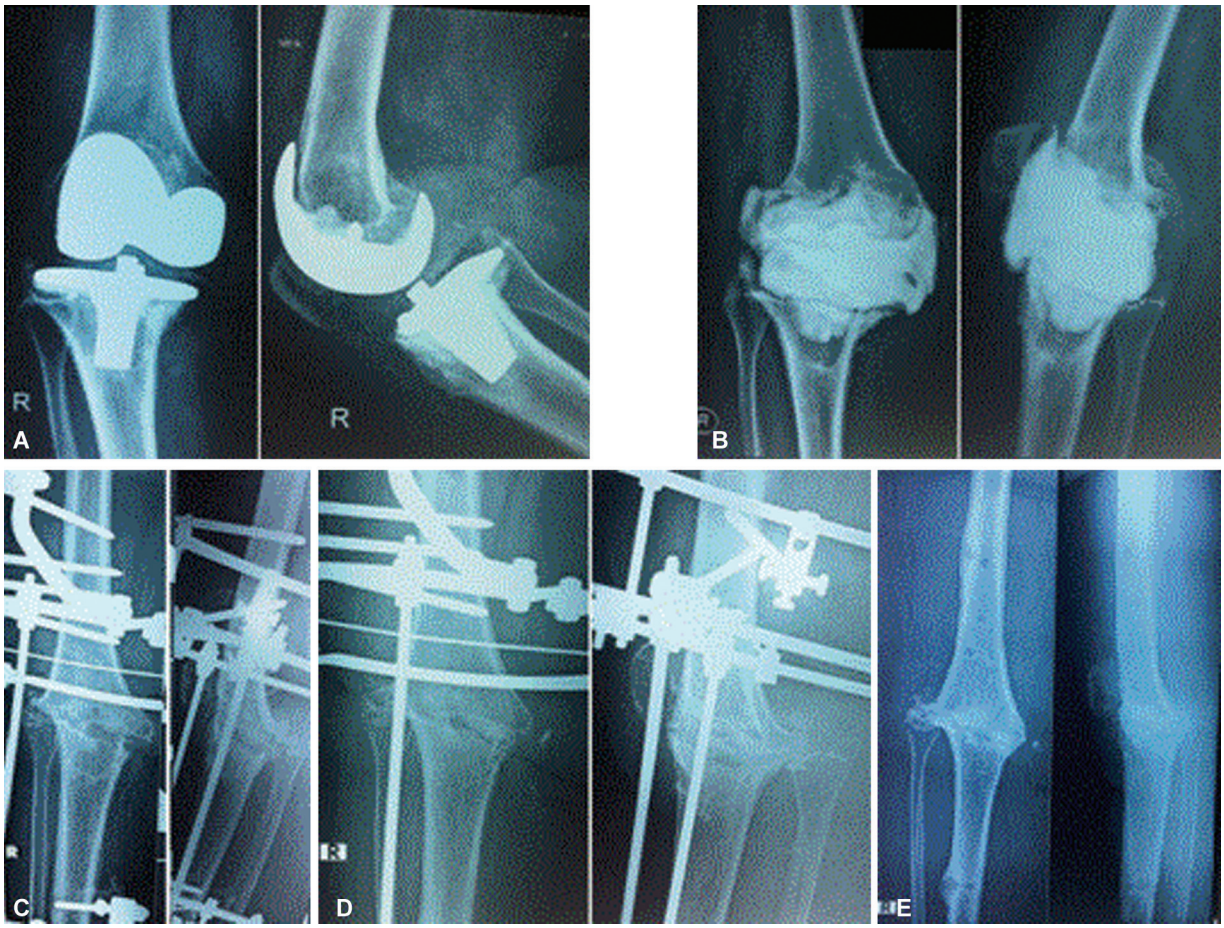
The functional assessment was done by Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index questionnaire [9] that consists of 24 items divided into three subscales that are pain (five items), stiffness (two items), and physical function (17 items). The test questions are scored on a five-point Likert scale (none=0; mild=1; moderate=2; severe=3; and extreme=4). Hence, the higher WOMAC scores indicate worse pain, stiffness, and functional limitations. The mean preoperative WOMAC index score was 80.31 (SD, 2.02; range, 77–84).

Table 1 Demographics and characteristics of patients

Patient number	Age	Sex	Side	Indications for primary TKA	Time from the primary TKA to knee fusion (months)	No. of previous surgeries	Preoperative WOMAC score
1	61	F	Lt	OA	29	6	79
2	65	F	Lt	RA	20	4	81
3	56	M	Rt	OA	19	4	78
4	60	F	Rt	OA	18	3	78
5	58	F	Lt	OA	28	5	79
6	65	F	Rt	OA	24	5	81
7	79	M	Lt	OA	18	4	84
8	66	M	Lt	OA	24	4	81
9	71	F	Rt	OA	20	5	82
10	56	F	Rt	RA	30	6	82
11	55	M	Lt	OA	37	6	77
12	74	F	Rt	OA	21	5	80
13	67	F	Rt	OA	19	3	82

F, female; Lt, left; M, male; OA, osteoarthritis; RA, rheumatoid arthritis; Rt, right; TKA, total knee arthroplasty; WOMAC, Western Ontario and McMaster Universities Osteoarthritis.

Figure 1



A right infected TKA in a 71-year-old female. (a) Radiographs with evidence of implant loosening. (b) Preoperative radiographs showing the bone cement spacer implanted as a first stage for planned revision TKA. (c) Radiographs after implant removal and frame application. (d) Radiographs showing fusion. (e) Radiographs after frame removal with sound fusion.TKA, total knee arthroplasty.

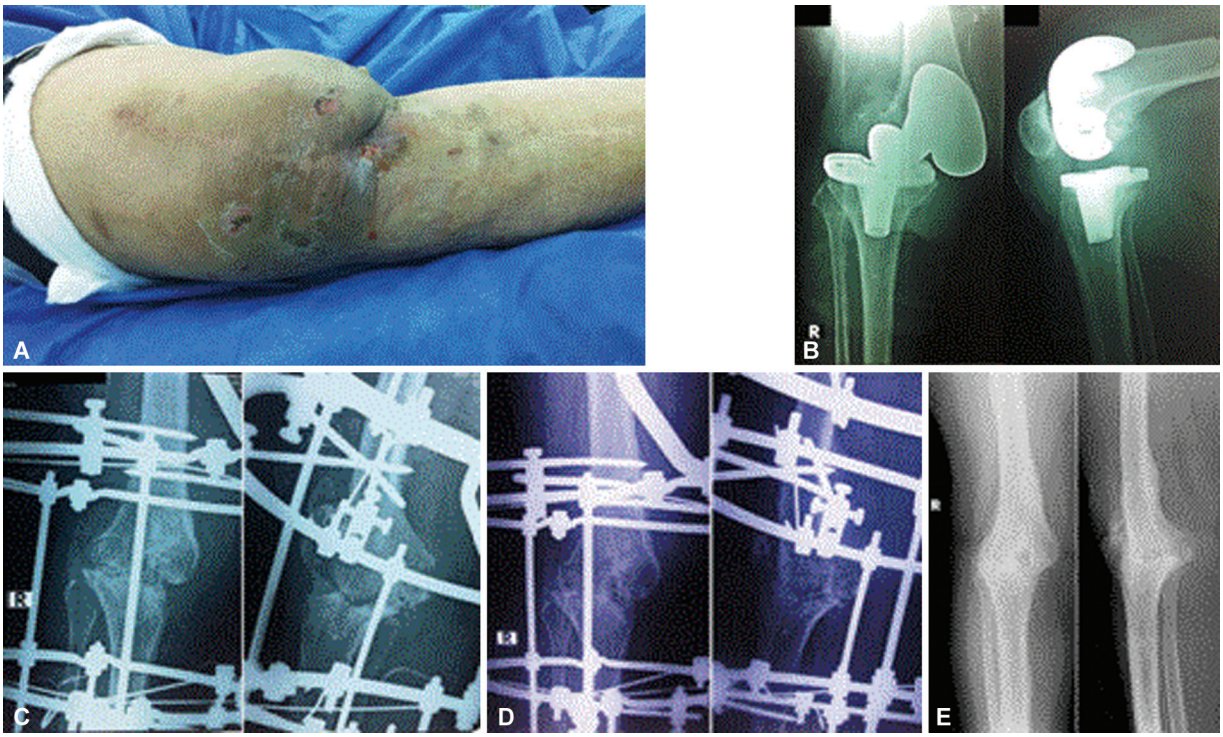
The operative technique and its possible complications including the functional limitations imposed by arthrodesis were discussed in details with the patients preoperatively to avoid unrealistic postoperative expectations. Acceptance of this management plan was not difficult for patients who were in pain with severe functional limitations after repeated surgical procedures. Preoperative optimizing comorbidities and smoking cessation were imperative. Informed consent was obtained from all patients.

Operative technique

The procedure was done under general or regional anesthesia in a supine position. A tourniquet was used during debridement. The exposure was carried out through the previous anterior longitudinal approach with a medial parapatellar arthrotomy. The sinus and the scar were excised along with the adequate thickness of soft-tissue flaps. Multiple deep soft tissue and bone samples were taken for cultures. A thorough debridement was done including removal of the prosthetic components, cement, spacers, all infected soft tissues, and necrotic bone tissues with repeated irrigation by normal saline. The bone surfaces were then prepared using an osteotome till having bleeding cancellous bone surfaces adequately flat for compression. Temporary stabilization was done using two percutaneous crossed 2.5 mm wires. The tourniquet was deflated after wound irrigation and closure over a suction drain.

Then, the Ilizarov fixator was applied to the tibia and femur with a two ring-block tibial component and a femoral component of one ring and an arch. Each ring was stabilized with two to three 1.8-mm wires tensioned to 130 kg. Half-pins were added to strengthen the construct. The arch was fixed by two to three half-pins. The tibial and femoral constructs were then connected by four threaded rods with maximum possible tibiofemoral contact in a final position of neutral rotation, a tibiofemoral angle of 5–7° valgus, and flexion of 0°.The foot was left partly exposed to control rotation and evaluate the circulation throughout the procedure.

Figure 2



An infected right TKA in a 67-year-old female. (a) Clinical picture showing active infection. (b) Preoperative anteroposterior and lateral radiographs. (c) Postoperative radiographs after implant removal and Ilizarov fixator application. (d) Radiographs showing evidence of fusion. (e) Radiographs after 2 years of sound arthrodesis.TKA, total knee arthroplasty.

Postoperative care

Compression was started from the second postoperative day at the rate 1 mm/day till the radiological appearance of complete compression. Weight bearing was allowed, as tolerated, reaching full weight bearing with complete fusion. The patients were educated and taught pin site care. On the basis of the culture/sensitivity reports of the previous swabs, antibiotics were given at induction of anesthesia and postoperatively for 6 weeks. Patients with quiescent infection were given a combination of aminoglycoside and cephalosporin for 3 days, then, cephalosporin alone for 6 weeks. The antibiotic choice was changed, if necessary, according to the culture/sensitivity results of intraoperative samples. Anticoagulant therapy with low-molecular-weight heparin was given to all patients.

Follow-up was done weekly for the first month, monthly until fusion, and then every 6 months. The patients were clinically assessed for wound status, pin site care, and weight bearing. Radiographs were checked for the compression status, maintenance of position and alignment, and progression of fusion. The Ilizarov fixator was removed after achievement of sound fusion evidenced radiographically by the presence of bridging trabeculae and clinically by painless weight bearing with a loosened frame. An extension knee brace was used for 4 weeks. The final follow-up assessment was done clinically for stability, alignment, leg length discrepancy (LLD), and recurrence of infection and radiographically for fusion, alignment, and signs of persistent infection. Patient satisfaction was recorded as very satisfied, satisfied, somewhat dissatisfied, or dissatisfied. The functional assessment was done by the WOMAC index.

Statistical analysis

Wilcoxon's signed-rank test was used to compare the mean preoperative and postoperative WOMAC index scores. Level of significance was set at P value less than 0.05. The descriptive analysis and statistical analysis were performed with IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, New York, USA).

Results

The culture results showed the presence of *Staphylococcus aureus* in six cases and *Staphylococcus epidermidis* in five cases, and no growth in two cases. Bone grafting was not used in this case series. Patients were followed-up for a mean of 28.62 months (SD, 7.73 months; range, 18–42 months) (Table 2). The mean external fixator period (EFP) was 7.77 months (SD, 1.17 months; range, 5–9.5 months). After frame removal, infection was controlled in all patients

Table 2 Summary of patients' results

Patient number	Follow up (months)	EFP (months)	Fusion	Alignment		Mean LLD (cm)	Postoperative WOMAC score	Satisfaction
				Valgus	Flexion			
1	36	7	Yes	5°	0°	4	23	Very satisfied
2	20	5	No	–	–	4.5	51	Somewhat dissatisfied
3	42	7.5	Yes	0°	5°	3.5	25	Very satisfied
4	36	9	Yes	2°	3°	4.5	27	Satisfied
5	40	8	Yes	0°	2°	4	24	Very satisfied
6	28	7.5	Yes	3°	5°	3.5	26	Very satisfied
7	24	8	Yes	5°	0°	5	28	Satisfied
8	24	8.5	Yes	3°	3°	3.5	29	Satisfied
9	27	9	Yes	5°	4°	4	24	Very satisfied
10	21	9.5	Yes	5°	0°	3.5	28	Satisfied
11	30	7	Yes	3°	2°	3.5	26	Very satisfied
12	26	7	No	–	–	4	53	Somewhat dissatisfied
13	18	8	Yes	3°	4°	4	27	Satisfied

EFP, external fixation period; LLD, leg length discrepancy; WOMAC, Western Ontario and McMaster Universities Osteoarthritis.

without recurrence till the last follow-up. All cases had successful fusion except two diabetic patients. These two cases, in spite of having an unstable knee, were able to ambulate with the use of a brace and a crutch. They declined any revision surgery. The mean LLD was 3.96 cm (SD, 0.48 cm; range, 3.5–5 cm). Hence, a shoe lift was needed in all patients. The arthrodesed knees had a mean sagittal tibiofemoral angle of 2.55°(SD, 1.92°; range, 0–5°) flexion and the coronal tibiofemoral angle ranged from 0 to 5° valgus (mean, 3.09°; SD, 1.87°).

All patients did not have any rest or night pain. Functionally, the patients had some difficulty in bending over, climbing stairs, getting in/out of the car, putting on socks, and performing heavy work. However, all were able to bathe, dress, and perform light activities with a stable painless knee. A cane was used for outdoor activities in all cases. Difficulty to walk on uneven surfaces was reported in nine cases. The Wilcoxon signed-rank test showed a statistically significant improvement (Z=-3.186, P=0.001) of the postoperative WOMAC index score (mean, 30.08; SD, 9.89; range, 23–53) from the preoperative WOMAC index score (mean, 80.31; SD, 2.02; range, 77–84). The two pseudoarthrosis cases had the worse postoperative WOMAC scores of 51 and 53. Patient satisfaction was expressed as very satisfied in six patients, satisfied in five, and somewhat dissatisfied in the two nonunions.

Complications

The postoperative hematoma was surgically evacuated in one patient. A repeat debridement procedure was needed in two patients while being in the frame before fusion. Superficial pin track infection occurred in 10 cases and treated by oral antibiotic and pin site dressing. Infected pin loosening necessitated pin exchange in one case. Breakage of a half pin occurred in one patient during frame removal. Pseudoarthrosis developed in two patients. No refractures or neurovascular complications reported in this study.

Discussion

Deep infection is a very serious complication of TKA causing severe patient morbidity and generating tremendous economic costs [10–12].Treatment modalities of infected TKA include repetitive debridement, staged revision arthroplasty, prosthesis retention, chronic antibiotic suppression, arthrodesis, or amputation [13,14]. Staged revision arthroplasty can preserve the joint; however, it can be associated with significant morbidity, added economic costs, and much higher rates of infection [10,13,14]. Mortazavi *et al.* [15] reported reoperation for infection in 28% of 117 infected TKAs treated by two-stage revision arthroplasty. Zmistowski *et al.* [16] reported infection control rate approximating 50% in gram-negative and methicillin-resistant infections. Hanssen *et al.* [17] reported failure to control infection in 23 (96%) knees in a series of 24 reinfected knees. Resection arthroplasty, as an alternative method, to eradicate infection is disadvantaged by pain and knee instability [18]. Definitive management of uncontrollable infection may consist of knee arthrodesis or amputation. Amputation is a more invasive and invalidating procedure for the patient [12,19].

Arthrodesis remains a well-recognized salvage procedure to avoid amputation [20,21].One-stage and two-stage arthrodesis approaches have been described. In the first approach, explantation, debridement, and fixation are done in a single stage. The second approach included the first stage of debridement, implant removal, and placement of antibiotic-impregnated cement spacer, followed by a 6- to 8-week antibiotic course, then the second stage of fixation by the preferred method [1,3].

Variable techniques have been used to achieve knee arthrodesis. The choice is between the more rigid internal fixation, and external fixation [22,23]. Using long IMN has achieved a fusion rate of 88–100% with the advantages of allowing early weight-bearing and high patient compliance. However, long IMN insertion is challenging with a high risk of proximal femoral fracture and is not advisable in patients with active infections. Hence, external fixation must be considered as it avoids implanting materials in septic tissues with a considerably lower risk of dissemination of infection.

Monoplanar fixators are easier to apply. However, the poor rate of fusion with higher complication rate has led to their infrequent use [5,19]. Ilizarov fixator has excellent stability allowing early weight bearing and versatility, facilitating finetuning of the alignment. Focal compression and distraction can be used to enhance fusion, thus, alleviating the need for bone grafting. Moreover, it can be applied in the presence of active infection. Its main disadvantages include the complexity of the application, frame bulkiness, and the risk of complications, such as pin-tract infection [12,24].

Many surgeons prefer a two-stage approach independent from the surgical technique used for arthrodesis [3,5,8,13,14,21].With the single-stage approach in the current series, successful arthrodesis was obtained in 11 (84.6%) cases with mean EFP of 7.77 months. One of the two pseudoarthroses did not tolerate the frame for more than 5 months. In the other case, the fusion soundness was overestimated in soft radiographs. Good quality radiographs or computed tomographic scans are therefore recommended before frame removal in doubtful cases. Although having nonunion, these two cases were ambulant and could cope with daily living activities with a brace and a crutch. This fusion rate was consistent with other reports using Ilizarov fixator for infected TKA. Bruno *et al.* [19] reported complete fusion in 15 patients and four nonunions. They reported a longer mean EFP in septic than in aseptic TKA failure patients (12.4 vs. 8 months). Kuchinad *et al.* [25] achieved fusion in 15 of 16 (93.8%) patients with an average EFP of 13.1 months in seven patients with simultaneous bone lengthening and 9 months in the nonlengthened group. Oostenbroek and van Roermund [11] reported fusion in 14 of 15 cases with mean EFP of 28 weeks. The lowest fusion rate using the Ilizarov frame was obtained by Garberina *et al.* [26] in a series of 19 patients with mixed indications, namely; loose or infected prostheses, pyarthrosis, and post-traumatic arthrosis. Nonunion occurred in 6 (32%) patients. The authors reported above-knee amputation in two patients. The rate of amputation following TKA was reported to range from 0.02 to 6% [5].Amputation was not needed in any of our cases.

Bone grafting was not used in the present series and repeated cycles of compression/distraction were relied on to enhance fusion. There is no consensus about the use of bone grafts while performing a knee arthrodesis [19]. On using Ilizarov fixator for knee fusion, few authors reported the use of the patella for grafting [8,11] while others did not use any bone grafts [19,22,27].

In the current series, two cases required a debridement procedure during external fixation. Thereafter, infection was controlled in all cases until the last follow-up visit. Infection was considered to be in remission by the absence of clinical signs with normal biochemical parameters at the last follow-up [23]. Several studies reported infection control in all cases [11,12,23]. Variable rates of infection recurrence were reported after arthrodesis of infected TKA. Infections were controlled in 16 of 17 patients in the study of Balci *et al.* [5] after using unilateral external fixators. Razii *et al.* [28] reported infection recurrence in 2 of 12 infected TKA cases treated with a long IMN. Röhner *et al.* [29] reported a higher rate of persistent infection in 13 of 26 cases of infected TKAs treated with a two-stage IMN. Schwarzkopf *et al.* [1] used different fixation methods (IMN, plate fixation, external fixation, and cancellous lag screws) for arthrodesis in the same study and reported infection in 11 of 43 failed TKA.

The arthrodesis alignment, in the current study, was adequate with a mean frontal tibiofemoral angle of 3.09° valgus and mean knee flexion of 2.55°. There is no global consensus regarding the best position of knee arthrodesis. Although fusion in 15° of flexion allows a better sitting position, it also increases LLD. Most authors prefer a neutral position (0° extension) to

prevent further limb-shortening while others prefer a slight flexion (5–10°) [18,19]. On the frontal plane, 5–7° of valgus has been proposed as the ideal alignment. This is easy to gain with external fixator while using IMN often places the knee at 2–5° of varus increasing the varus moment on the ipsilateral hip joint [30]. Several studies did not report on the results of the final arthrodesis alignment [3,8,11,12,27]. Leroux *et al.* [6] reported mean tibiofemoral angles of 178.6° of varus and 1.9° of flexion. In their study, Balci *et al.* [5] reported a mean coronal alignment of 6.8° valgus and mean flexion of 11.3°. Watanabe *et al.* [14]reported an average femorotibial angle and lateral flexion angle of 175 and 4.6°, respectively, with one case of 9° hyperextension. However, they did not identify femorotibial angle as being varus or valgus.

The average LLD in the present study was 3.96 cm. For that, we aimed at 0° of extension alignment and a shoe lift was used by all patients with under correction of about 1.5 cm. A slightly foreshortened, fused leg allows easier clearance during the swing phase of gait. When the leg is too short, a shoe lift may be used [31]. Balance issues occur more frequently as the lift height increases, especially when a lift height of 5 cm or more is required. Leg lengthening is considered for symptomatic LLD that cannot be satisfactorily treated with a shoe lift [21,24]. Our reported LLD rate is comparable with the reports of other authors (4.5 [3], 4.4 [8], 4 [11,19], 5.4 [14], 5.7 [25], 3.8 cm [27]). Different functional outcome scores were reported in some studies, namely, Japanese knee osteoarthritis measurement [14], Oxford Knee Score [32], Arthritis Impact Measurement Scale [33], Short Form-36 Health Survey [34], the lower extremity functional score [34], and WOMAC index score [6,29]. In the current study, the functional outcome improved with stability and pain alleviation. The overall WOMAC score improved significantly from 80.31 preoperatively to 30.08 at the last follow-up. Leroux *et al.* [6] reported a mean WOMAC score of 26 after two-stage knee arthrodesis with IMN and autologous bone grafting. Röhner *et al.* [29] reported a less favorable outcome with a WOMAC score of 39±16.

The limitations of the current study are the retrospective nature and lack of control group. Also, the patients' number was small reflecting the paucity of cases. Comparing the results of this study with others was difficult and should be cautiously interpreted. First, most studies are too small for comparative statistical analysis. Second, some studies used different fixation methods for arthrodesis in the same series [1,3,25]. Moreover, some reports are heterogeneous, mixing septic and nonseptic etiologies [1,19,22,23,25,26,34]. Finally, the diversity of the used functional outcome scores makes meaningful comparisons difficult [14,29,32–34].

Conclusion

Knee arthrodesis by Ilizarov fixator for the management of the challenging cases of infected failed knee arthroplasty achieved high fusion and infection control rates. Successful arthrodesis provided a stable limb with good pain relief and satisfaction, as well as improvement in function and quality of life.

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Conflicts of interest

There are no conflicts of interest.

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