Knee arthrodesis as a salvage procedure for infected total arthroplasty and chronic septic conditions of a knee joint using Ilizarov

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Background
Knee arthrodesis has been performed since the early 1900s for a variety of indications. Ilizarov principles of hybrid fixation have enabled surgeons to achieve independent ambulation in all patients and resulted in fusion in most patients available for follow-up evaluation. Numerous treatments have been proposed for infected total knee arthroplasty. In selected patients, a knee arthrodesis is a well-known salvage procedure. This article reviews an experience with this technique in infected total knee arthroplasty and chronic septic knee conditions not a candidate for arthroplasty.

Patients and methods
Eleven patients (four men and seven women) were treated between January 2007 and December 2009 by arthrodesis using the Ilizarov apparatus. Nine patients with an active infection underwent a two-stage procedure (debridement, followed by arthrodesis). The remaining two patients had no evidence of active infection (acute-phase reactants were within normal limits and/or no discharging sinus) and underwent one-stage arthrodesis. The mean age of the patients was 58.1 years (range 41–75 years). From the time of frame removal, the patients were followed up for a mean of 21.4 months (range 10–39 months). Partial weight bearing was allowed 1 week after surgery. All patients achieved a stable knee arthrodesis after a mean duration of 5.2 months without additional surgical procedures or bracing.

Results
Fusion was achieved in all the patients. There were no recurrent infections. All patients could walk without walking aids. At the end of the follow-up period, limb shortening was evaluated and ranged from 1 to 2.5 cm (mean 1.3 cm). Pin-tract infections were found in all cases, all of which were successfully treated with oral antibiotics and local wound care. Pain was analyzed preoperatively and postoperatively using visual analouge scale, with a mean flexion of 7.81 (range 0–121) and a mean valgus of 7.11 (range 4–121). No persistent infection was found clinically at the end of the follow-up period. No implant failure occurred in any of the cases.

Conclusion
Knee arthrodesis by the Ilizarov method for infected knee conditions is a very useful method, particularly in patients with extensive bone loss, significant axial deformity or both, chronic septic conditions (multiple debridements, muscle atrophy, multiple healed sinuses, bone loss, critical skin conditions and disfigurement), or previous failed infected arthroplasty.

Keywords:
Ilizarov arthrodesis, infected knee, salvage procedure

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Introduction

Knee arthrodesis is being performed since the early 1900s for the treatment of pain and instability because advanced osteoarthritis, post-traumatic arthritis, infectious arthritis, Charcot arthropathy, poliomyelitis, and reconstruction following tumor resection [1].

The success of modern knee arthroplasty has led to a decrease in the number of patients who would have been candidates for a knee arthrodesis. Currently, the most common indication for knee arthrodesis is an unreconstructable knee following an infection at the site of knee arthroplasty [2].

Arthrodesis is also indicated when there are extensor mechanism disruptions, poor bone stock, and poor soft-tissue envelope, and in young, active patients [3].

Arthrodesis by internal fixation either by a plate or by an intramedullary nail provides rigid fixation. Intramedullary nailing has the advantage of allowing early weight bearing, and has a high rate of fusion, ranging from 88 to 100%. However, it has the disadvantage that it can be applied

only after the infection has been treated successfully, which may take up to 40 weeks, and it still carries the risk of dissemination of latent infection [4].

In contrast, external fixation offers possible progressive adjustment to stimulate the bony fusion and to correct malalignment, and there is a considerably lower risk of intramedullary dissemination of the infection, and the hardware can be removed easily [5].

The aim of this study is to evaluate the efficiency of a circular external fixator for knee arthrodesis in patients who are not candidates for arthroplasty, namely, those with infected prosthesis and chronic septic knee conditions with bone loss and massive soft-tissue atrophy.

Patients and methods

Eleven patients, who had undergone knee arthrodesis using the Ilizarov external fixator from 2007 to 2010, were evaluated retrospectively. The average age of the patients at the time of surgery was 58.1 years (range 41–75 years). There were four men and seven women. The average follow-up was 21.4 months (range 10–39 months) (Table 1).

Indications for knee arthrodesis included long-standing chronic septic knee arthritis (four patients) and infected total knee arthroplasty (seven patients). Nine patients had active knee infection (high erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and/or discharging sinus) at the time of presentation (number 1, 2, 3, 5, 6, 7, 9, 10, and 11) (Table 1).

Seven patients (number 1, 2, 3, 5, 6, 9, and 11) with infected total knee arthroplasty had been managed by multiple debridements, and application of antibiotic-impregnated cement spacers 6 weeks before arthrodesis. Two patients (number 7 and 10) from the septic arthritis group had undergone proper debridement before arthrodesis because of an active infection.

In patients who had been managed by two-staged procedures, serial samples were obtained from the knee during debridement for culture and sensitivity. Patients were administered antibiotics accordingly for an average of 6 weeks; also, patients were subjected to laboratory investigations (acute-phase reactants) to ensure that remission of infection had occurred before the second operation otherwise another debridements.

Two patients (number 4 and 8) had severe clinical and radiological knee arthritic changes (massive periarticular bone loss and soft-tissue atrophy) secondary to a previous history of septic arthritis, with no clinical or laboratory evidences of active infection (normal ESR, CRP, healed,

Table 1 Patients' demographics

						VAS						Deformities	
Cases	Sex/ age	Indication	Medical condition	Operative stages	Number of procedures before arthrodesis	Pre	Post	Organisms	Follow-up (months)	Duration of external fixation (months)	LLD (cm)	FFD (degrees)	Valgus (degrees)
1	F/64	Infected TKR resurfacing		Two	4	8	3	SA	39	5	1.65	15°	–
2	M/66	Infected TKR resurfacing		Two	3	7	2	SA	32	6	2.1	25°	12°
3	F/49	Infected TKR resurfacing	Rh.A	Two	5	7	4	Mixed (PA, KB, SA)	29	4	1.8	20°	–
4	F/75	SAr sequelae		One	–	6	3	–	24	7	1.8	20°	–
5	M/62	Infected TKR hinged		Two	3	9	4	SA	21	5	2.3	25°	13°
6	F/48	Infected TKR resurfacing	Rh.A	Two	6	7	2	MRSA	20	4	1.5	Extension lag	–
7	F/65	SAr sequelae		Two	2	8	4	SA	19	5	1.65	15°	–
8	M/52	SAr sequelae	DM	One	–	7	2	–	17	4	1.5	Extension lag	–
9	M/41	Infected TKR resurfacing	DM	Two	3	7	2	SA	13	4	2.5	25°	14°
10	F/46	SAr sequelae	DM	One	–	6	2	–	12	5	1.8	20°	–
11	F/71	Infected TKR resurfacing		Two	3	8	2	KB	10	4	1.5	Extension lag	–

DM, diabetes mellitus; F, female; FFD, fixed flexion deformity; KB, *Klebsiella* spp.; LLD, limb-length discrepancy; M, male; MRSA, methicillin-resistant *Staphylococcus aureus*; PA, *Pseudomonas aeruginosa*; post, postoperative; pre, preoperative; Rh.A, rheumatoid arthritis; SA, *Staphylococcus aureus*; SAr, septic arthritis; TKR, total knee replacement; VAS, visual analouge scale.

or no sinuses), and the results of culture and sensitivity from samples obtained during arthrodesis were all negative, managed by one-stage arthrodesis.

The initial clinical evaluation includes a thorough assessment of the history of the patient's medical problems. Obesity, diabetes, and smoking increase the risk of wound complications and ideally need to be managed with a weight-loss program, a proper diabetic regimen, and a smoking cessation program. All previous incisions were considered at the physical examination. The surgical incision was planned in relation to other incisions in order to avoid wound necrosis.

Pain was assessed objectively using visual analouge scale in all patients and ranged from 6 to 9, with a mean of 7.27.

Range of motion was restricted in all patients with a loss of $\sim 25^\circ$ of extension and 35° of flexion.

Eight patients had fixed flexion deformity, with a mean of 20.62°, and three of them had a considerable valgus component, with a mean of 13°.

Preoperative scanograms were used in determining the limb-length discrepancy (LLD). If LLD following the arthrodesis is anticipated to be greater than 3 cm, then options for limb lengthening simultaneously or following the arthrodesis were presented to the patient in the preoperative discussion. Three patients who had more than 3 cm LLD were excluded from this study Table 1.

Surgical technique

In all patients, the procedures were carried out using the previously utilized anterior approaches. In patients who underwent a two-stage procedure, the first stage was to remove the infected implant (if present), all infected soft tissue and bone, and the application of an antibiotic-impregnated cement spacer. Culture-specific antibiotics were loaded into the cement in all seven cases with infected total knee replacement (TKR).

The steps of knee arthrodesis were almost the same in patients undergoing a one-stage or a two-stage procedure. The anterior approach was used to remove the skin scar; debridement was carried out to create bleeding surfaces in the surrounding soft tissues.

The spacer (three cases) was removed, and the bone ends were prepared to create wide, bleeding surfaces Fig. 1.

Resection guides from the instrument of TKR were used for the preparation of distal femoral and proximal tibial bone ends Fig. 2.

The position of fusion was maintained at 5–10° of flexion and 7° of valgus by the preliminary application of two crossed K wires under the guidance of an image intensifier Fig. 3a.

Knee position was determined using an intraoperative malalignment test using the wire of the electrocautery device Fig. 3b.

Once the knee position was stabilized in the desired alignment, the wound was closed before application of the external fixator, using monofilamentous surgical threads, in order to decrease the risk of infection.

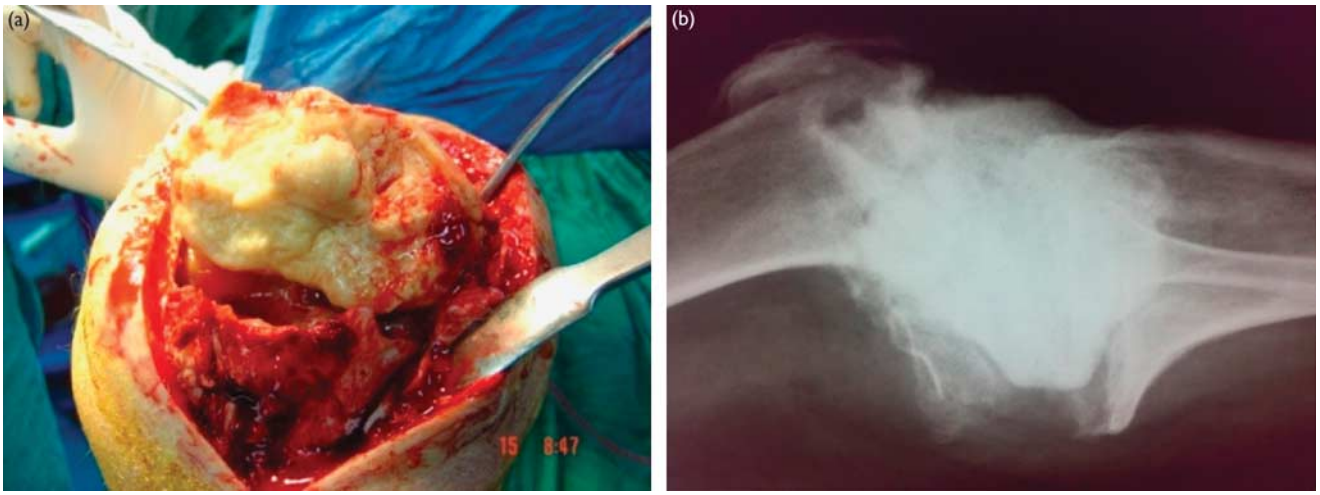
The external fixation frame for knee arthrodesis consisted of two full tibial rings: one femoral ring and a femoral arch transfixing the bone by thin wires and half-pins Fig. 4.

Compression across the fusing site was maintained postoperatively by applying a weekly shortening of 1 mm.

Partial weight bearing was allowed by the first postoperative week; patients were discharged after 5 days unless wound complications or other medical condition were present.

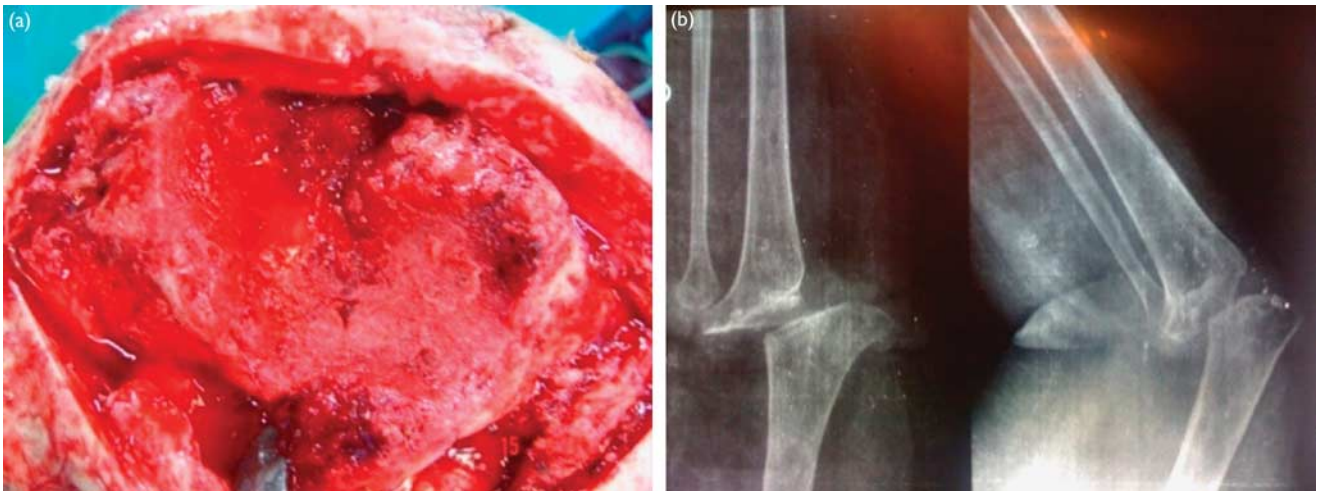
Postoperative radiography was evaluated for evidence of bony fusion. This was detected by trabecular bridging between the tibia and the femur. Radiographic evidence

Figure 1



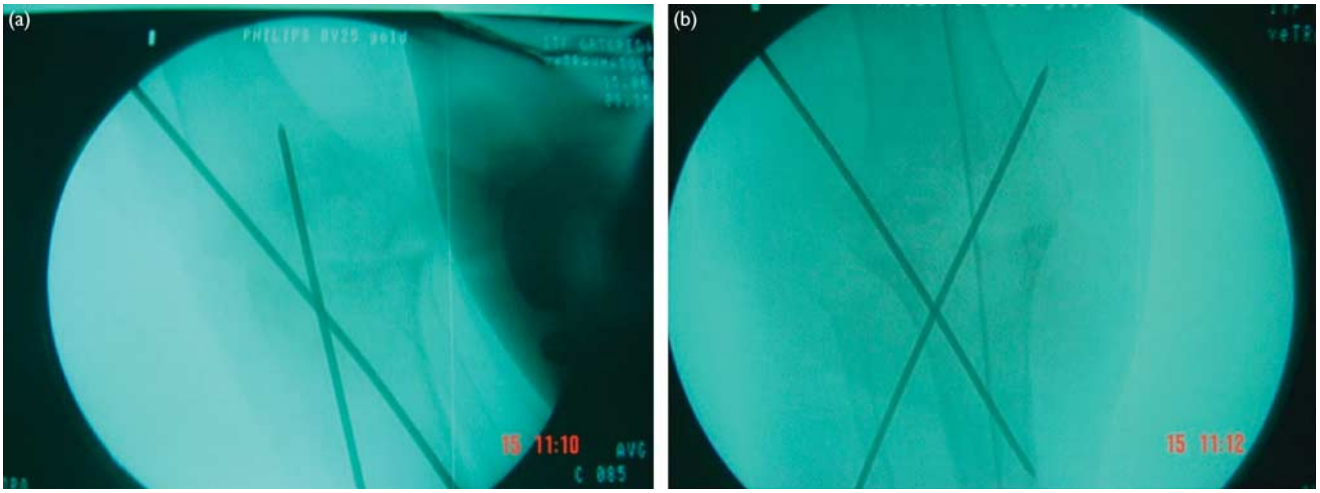
(a) Cement spacer (intraoperative), (b) cement spacer (radiograph).

Figure 2



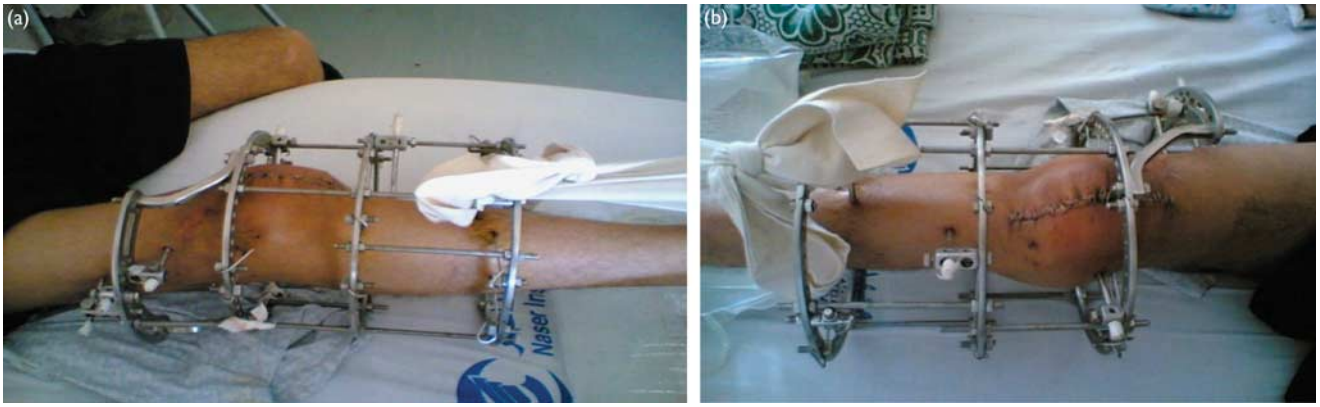
(a) Bone defect following the removal of the cement spacer and the creation of wide healthy bone contact. (b) Radiograph following the removal of the spacer and proper debridement.

Figure 3



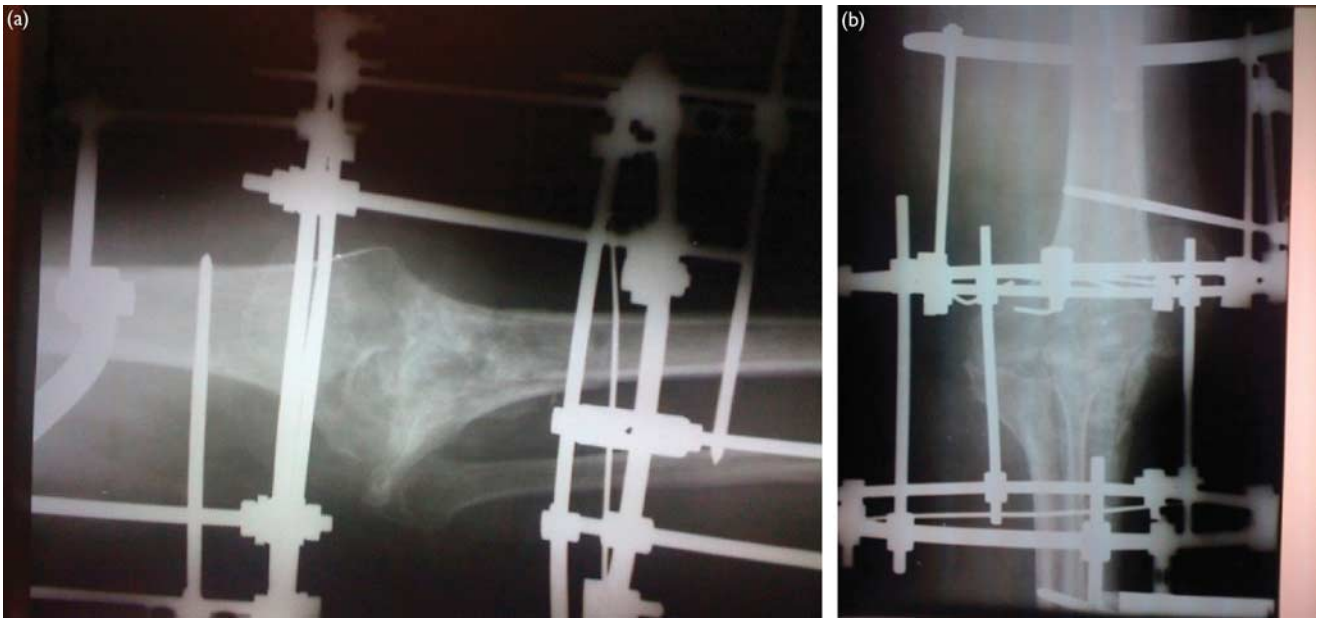
(a) Temporary fixation of the position of knee arthrodesis by two crossed K wires. (b) Checking the mechanical axis of the limb using an electrocautary cord stretched from the center of the femoral head to the center of the ankle joint.

Figure 4



Frame design from the (a) lateral aspect and (b) the medial aspect.

Figure 5



Radiograph after 1 month: postoperative (a) anteroposterior view and (b) lateral view.

of fusion coupled with no evidence of motion on clinical examination after the removal of the fixator were the criteria for successful arthrodesis Fig. 5.

After complete radiological fusion, the frame was removed and the patient was re-evaluated clinically and radiologically Figs 6 and 7.

Results

Consolidation was achieved in all patients by a mean of 5 months (range 4–7 months). After the removal of the frame, patients were instructed to wear a knee brace for 3 months, followed by assisted walking using canes for another month. At the end of the follow-up, all patients could walk without walking aids.

In all patients, infection was completely eradicated, with no evidence of recurrence during the follow-up period. The position of the arthrodesis showed a mean flexion of 7.8° (range 0–12°) and a mean valgus of 7.1° (range 4–12°).

Despite regular care of pin sites, all patients developed pin-tract infection. These were managed successfully by local debridement and meticulous pin site care, but occasionally necessitated short-term antibiotic treatment. These infections were mostly observed in areas with abundant soft tissue, especially the thigh. No deep infections occurred, no neurovascular complications were encountered, and none of the limbs was lost. No implant failure or loosening occurred during the framing period.

Patients (number 2, 5, and 9) had an average of 2.3 cm shortening (range 2.1–2.5 cm) at the end of the treatment and received shoe lift and could walk without an assistive device. In the remaining patients, the average postoperative shortening was 1.65 cm (range 1.5–1.8 cm).

Discussion

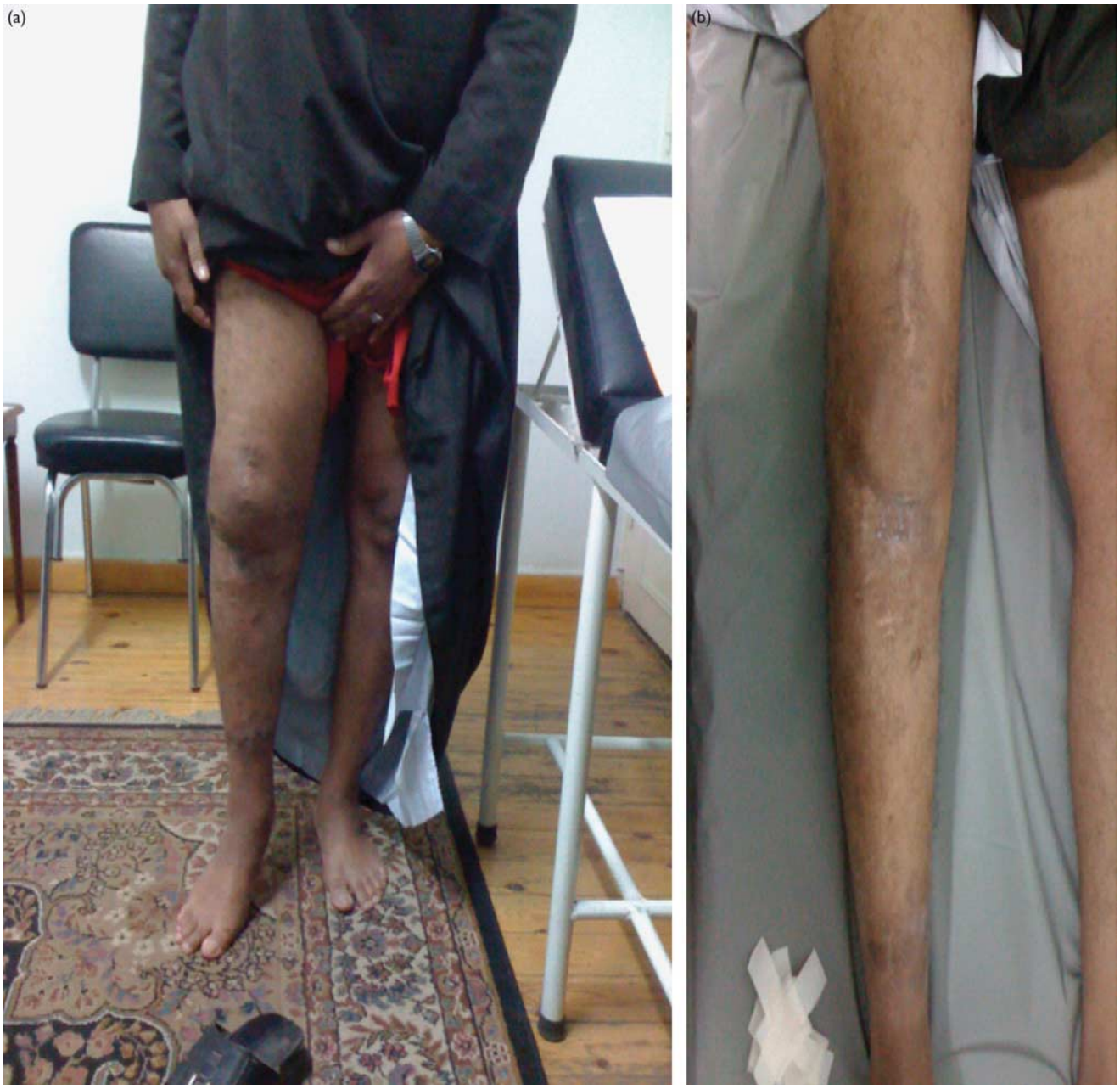
Patients who have undergone several unsuccessful attempts at revision total knee arthroplasty may be left with the dilemma of having to choose among amputation, pseudarthrosis, or arthrodesis. Successful arthrodesis offers the possibility of continued independent living, with a sensate, stable extremity. If fusion is achieved, it is associated with a marked relief of pain and a low rate of reinfection [6–12].

The indications for knee arthrodesis in this work were primary infectious of origin. All patients in this work achieved successful fusion and were able to function as a community ambulatory. This high fusion rate can be attributed to the proper eradication of the infection, surgical technique, and the optimum application of the external fixator. Many authors have reported these conclusions [8,11,12].

Contraindications to knee arthrodesis are contralateral knee amputation, contralateral knee or hip arthrodesis, and degenerative changes in the ipsilateral hip and ankle. Patients with degenerative arthritis of the spine are also poor candidates for knee arthrodesis because the compensatory pelvic tilt, required during walking, increases forces across the lumbar spine [9]. In this work, we excluded patients with all the previous conditions, and also those with LLD more than 2.5 cm.

Maximum bone contact and apposition are very important to achieve knee fusion [6,7,13–15]. Charnley [1] believed that the success rate of 99% (169) of the 171 arthrodesis

Figure 6



(a) Patient standing after removal of the frame 5 months postoperatively, (b) the same patient in a supine position with a proper mechanical axis.

in his patients was because of two perfectly coapted surfaces of cancellous bone, with intact circulation. Hageman *et al*. [8] believed that the most important factor for a successful fusion was good bone contact.

In this work, wide bony contact was ensured by preparing the distal femoral and the proximal tibial surfaces using a tibial resection guide from TKR instruments.

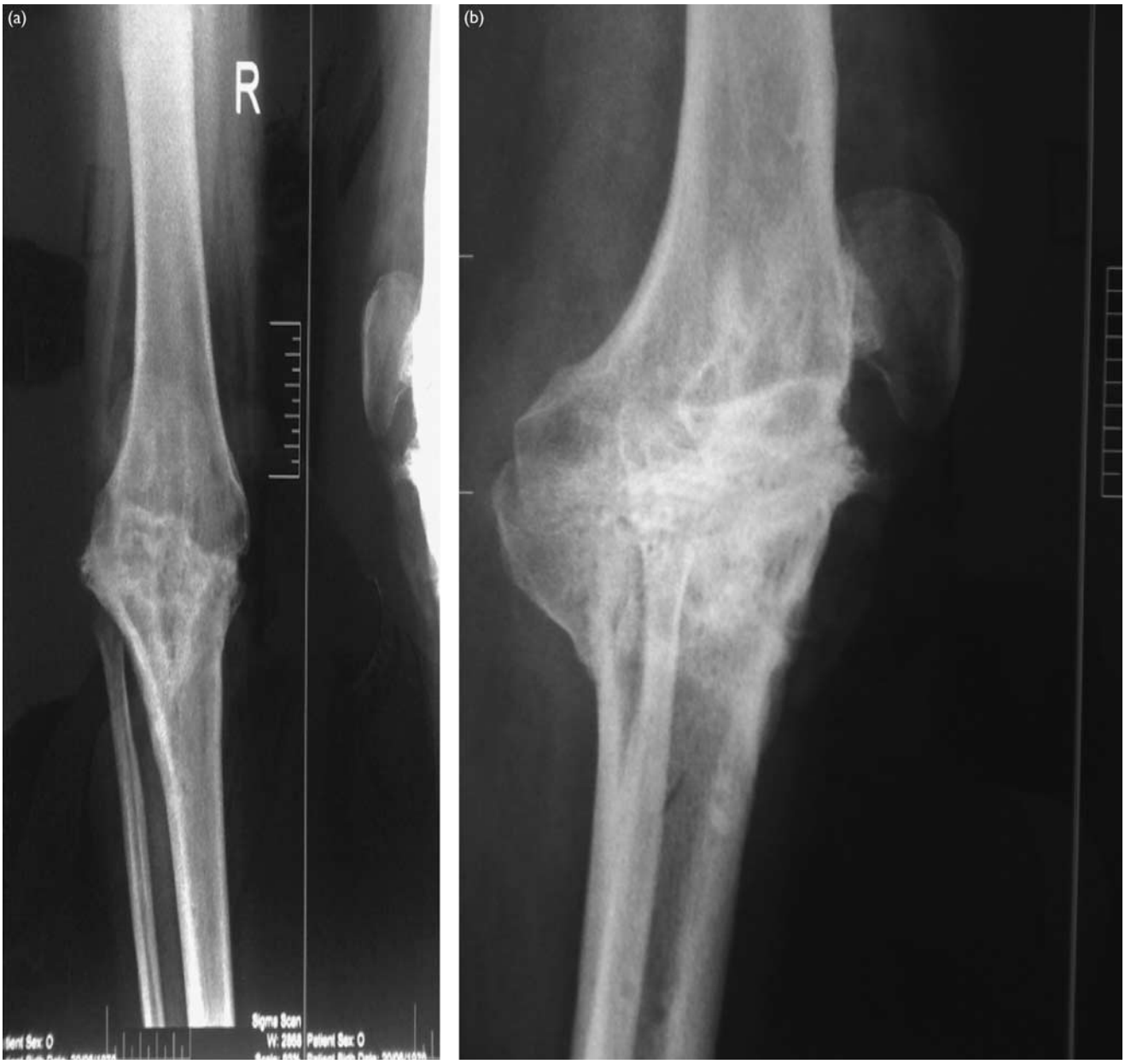
There is no consensus on the optimal alignment of a knee fusion in the sagittal or the coronal plane. Some authors have reported that in order to prevent further limb shortening, the majority of the knee arthrodeses should be placed in 0° extension [7,14–17]. Some authors have recommended 5–10° of flexion [13,18,19].

Fusion at 10–15° of flexion allows a better sitting position and improves the gait, but increases LLD [7].

All patients with active infection underwent a two-stage procedure in which debridement and application of antibiotic-impregnated cement was carried out in the first stage, followed by arthrodesis in the second stage after the infection had been eradicated (average 6 weeks).

A two-stage procedure in the presence of active infection provides the best chance for successful fusion; this has been supported by many studies that have clearly shown that if the infection was treated successfully before the arthrodesis was attempted, there was a significant increase in the chances of a successful fusion [7,9,10,18–20].

Figure 7



Anteroposterior view shows complete arthrodesis at the end of the follow-up period (13 months) (a), lateral view of the same case (b).

The initial operative treatment consists of surgical debridement, removal of the prosthesis, and insertion of an antibiotic-impregnated bone cement spacer, followed by ~6–8 weeks of oral antibiotics. The antibiotics are then discontinued and, if no increase in blood parameters (CRP, ESR) is found after 2 weeks, an arthodesis is performed, followed by antibiotics until normalization of the blood parameters.

Although arthrodesis by an intramedullary nail has a high fusion rate up to 95%, and allows early weight bearing [11,12], it has many disadvantages including the risk of infection dissemination, technical difficulty in maintaining adequate degrees of flexion, and valgus, long operative duration, huge intraoperative blood loss, nail migration, intraoperative fracture, and inability to maintain postoperative compression [13–16].

Nichols *et al.* [17] studied the use of dual plates to achieve knee arthrodesis; a fusion rate of 100% was achieved in 11 patients. The authors suggested avoiding this technique if gross or acute infection was present [17]. More data on the effectiveness of this technique are required to determine the role of dual plates in knee arthrodesis [18].

The use of an Ilizarov external fixator is technically demanding, requires a compliant and dedicated patient, and may lead to the development of complications including pin-tract infections, pin breakage, premature

or delayed consolidation of regenerate bone, transient nerve palsies, and distal joint contractures [14].

Nevertheless, this therapeutic modality has unique advantages over other techniques in the fusion of large joints, especially in the presence of active infection coupled with poor bone quality, when the technical benefits it confers overshadow the potential complications, provided the treatment is carried out by a skilled team, with strict adherence to indications.

Competent knowledge of the modularity of the device and awareness of the potential complications, which are sometimes unforgivable, pays off in the high success rate of fusion.

When applied properly, this frame provides stable immobilization of the joint in three planes with stable fixation against shear and torsion stress, whereas axial loading is allowed without a detrimental effect on the fusion site [15].

Micromovements in the axial plane persist, stimulating bone formation, and enhance osseous healing. The newly formed bone conforms to Wolf's law. Hence, early ambulation and weight bearing may be encouraged and can be initiated almost immediately [16].

The use of an Ilizarov device in knee arthrodesis has improved the success rate of fusion by external fixation markedly (93–100%) [19,20].

Spina *et al.* [21] studied a series of 17 patients, mean age 62.9 years, treated from 1990 to 2007 with femoral–tibial fusion. They used the Cierny–Mader classification for clinical and anatomopathological evaluation; the Engh classification was used to assess the bone defect. Surgical treatment differed according to these criteria. Thirteen out of 17 of their patients achieved healing at the first surgical attempt in a mean time of 9.3 months. The mean duration of follow-up was 30 months. Of the four complications that were encountered, two patients had an intolerance to the external fixator that led to its early removal, and the other two had a septic intra-articular nonunion.

Calif *et al.* [22] studied compression arthrodesis using an Ilizarov frame which was used in six badly disrupted knees in a series of 20 patients. Evaluation of the results was carried out on the basis of the clinical and radiological joint alignment, achievement of fusion, presence or absence of infection, and functional outcome. One patient was lost to follow-up after knee joint arthrodesis, and two knees developed a clinically stable fibrous union.

Oostenbroek and van Roermund [20] treated 15 patients by arthrodesis of the knee after the removal of an infected total knee arthroplasty using an Ilizarov ring fixator. Eight patients had a failed arthrodesis by another technique. The mean age of the patients was 75 years, the mean duration of retention of the frame was 28 weeks, the mean treatment time was 51 weeks, and the mean follow-up period was 52 months. All except one knee fused at the first attempt, a rate of union of 93%. The incidence of complications related to treatment was 80%. The length of treatment and the rates of complication were attributed to the older age of the patients and the adverse local clinical factors in these patients.

Feibel and Guy [23] presented a work that included 11 patients who had undergone an Ilizarov knee arthrodesis. Eight of them had failed total knee arthroplasty; all were found to have severe bone loss. Three out of those eight patients developed a pseudarthrosis. Two of these patients were fitted with an orthosis and the third underwent a successful Arbeitsgemeinschaft für Osteosynthesefragen double-plate fixation. Wires had to be removed because of infection twice. The average time to union was 4.5 months.

Conclusion

On the basis of this work, we recommend the Ilizarov method as an efficient clinical tool for achieving knee arthrodesis. The gross outcomes on the quality of life are similar to those that have been reported previously [11,20–24].

Although our study is limited by its retrospective nature, we believe that arthrodesis of the knee using Ilizarov is a satisfactory salvage procedure following a failed total knee arthroplasty or chronic septic knee conditions, and can provide reliable expectation for a stable, painless lower limb for patients who are able to walk. It is recommended that a two-stage procedure provides the best chance for a successful fusion in active and chronic infections irrespective of the species or the varieties of organism(s) isolated.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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