Trauma Case Reports 28 (2020) 100317

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

# Treatment of femoral defective osteomyelitis with minimal invasive plates

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A B S T R A C T

*Objectives:* Although recent treatment modalities reduced chronic osteomyelitis, it is still a challenging problem for both orthopaedic surgeons and patients. Especially treatment of femoral osteomyelitis with defective nonunion is reasonably difficult. Most accepted treatment option is external fixation. But the duration needed for external fixation may be too long for patient compliance. To reduce external fixation duration several methods were described. In this study we described a method for reconstruction of infected femoral defective nonunions using minimal invasive plates.

## Patients and methods

Five patients at an average age of 48.4 (40–61) were included in the study. All of the patients were male. All of the nonunions were chronic and septic. Stepped surgery was planned at the beginning of the treatment. At the first step, radical debridement was performed and all external or internal implants were removed. Bone was resected up to the healthy level. All necrotic soft tissues and sinus tracts were debrided. Samples for microbiologic examination were taken. After debridement, monolateral external fixator was performed. Acute or gradual compression was made. After regression of signs of infection; at the second stage, an osteotomy was performed and gradual distraction for osteoneogenesis was started. When defect was reconstructed, signs of consolidation were waited at the docking site. After appearance of consolidation signs, the third step was planned. At the third step, a temporary external fixator was performed from the anterior site. Then lateral external fixator was removed, pin sites were debrided. From openings of these inscisions, a locking plate was applied advancing submusculary. In the follow up controls x rays were taken and clinical scores were noted.

## Results

Mean follow up time was 38.4 months (12–60). months. All nonunions healed. Mean union time was 15.2 (8–20) months. Mean external fixator index was 15.27 day/cm. There is one paley 2, one paley 3 complications. All patients had pin track infections.

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https://doi.org/10.1016/j.tcr.2020.100317
Accepted 16 May 2020

**Conclusion**

To reduce external fixator time and patient discomfort, additional plate placement is a good option for treatment of defective femur septic nonunions.

**Keywords**

Femur
Osteomyelitis
Ilizarov technique
Minimal invasive

## Introduction

Femur osteomyelitis is still an important cause of morbidity. Although mortality has been reduced with the current treatment modalities, morbidity is still an important problem. The most important morbidity reasons include nonunion, shortening and chronic infection. The treatment of osteomyelitis remains still challenging [1].

In chronic osteomyelitis, not only the status of the bone but also the general body resistance of the patient is important. Here, the comorbidities of the patient play a crucial role. Thus, Cierny and Mader considered the local and systemic conditions in two different categories while classifying the bone into four groups in their classification; and developed a treatment schema [2]. In chronic osteomyelitis treatment, the systemic antibiotherapy and radical surgical debridement established the basis of the treatment. In the presence of nonunion, stable surgical fixation should be applied. The increase of resistant bacterias, especially the plaque-forming Staphylococcus, has reduced the efficiency of antibiotherapy. Therefore, surgical debridement has become more important [3]. However, a serious bone defect occurs after the wide resection of the bone. Both osteomyelitis and nonunion, and the emergent defect further complicate the treatment [4].

The Ilizarov technique has been used for many years in the treatment of osteomyelitis with defects. Although it has numerous complications, the results are good in general [5]. The Ilizarov technique is hard to learn and to apply [6]. Long-term use of external fixators is a challenging issue for the patients. For this reason, there has been search for solution to reduce the duration of external fixator. Intramedullary nailing following could be chosen. However, there is a high probability for infection relapse in this technique. In addition, the intramedullary nail should be custom made with an additional locking screw [7,8].

The significance of biology has been understood better not only in osteomyelitis treatment, but also in all bone fixation treatments. Therefore, minimal invasive methods are gaining significance nowadays especially in the femur fracture treatment [9].

This study aims at discussing the results of the patients to which we implemented external fixator, osteotomy, defect restoration and minimal invasive locking plate (internal fixator) following a wide debridement.

## Material-method

All of five patients, we had treated for femur infected defective nonunion, were included in the study retrospectively. The criteria for inclusion to the study were osteomyelitis and nonunion in the femur shaft region. The osteomyelitis diagnosis was made considering the drained sinus related to the nonunion line, elevated laboratory results (erythrocyte sedimentation rate and C reactive protein), nonunion and sequester appearance in plain radiography, isolation of microoragnisms in the post-operative culture samples. Aseptic defective nonunions, osteomyelitis developing after fracture union, and child patients were excluded from the study.

General patient and extremity examinations were performed. Additional diseases and habits like smoking-alcohol were noted. The number of previous operations was determined and the interventions were noted. Before the surgery full blood count, erythrocyte sedimentation rate and C reactive levels were checked for each patient. These values were controlled again at the end of the treatment. Open wound-sinus openings in the extremity, rash on the surrounding skin, old incision scars, deformities and shortness were noted. Distal circulation control was performed using peripheral pulse control. In case of incertitude, the controls were repeated using arterial Doppler. The neurological examination was performed considering the mobility in the lower extremities, muscle forces, tactile and pain sensation. Range of Motions of the joints of lower extremities were determined.

The height inequalities of the patients were determined by comparing the opposite extremity length. The lengths were obtained in centimeters by measuring the distance between spina iliaca anterior superior and medial malleolus using a measuring tape. The

**Table 1**
Patient demographics. (d.o.o.; duration of osteomyelitis, years. n.o.s.; number of surgeries. MRSA; methicilin resistant staphylococus aureus).

| Patient no | Age | Comorbitidy | d.o.o. | Etiology | n.o.s. | Deep tissue culture |
|---|---|---|---|---|---|---|
| 1. | 40 | Smoker | 0,5 | Gun shot | 3 | E. coli and Acinetobacter b. |
| 2. | 61 | Smoker | 10 | Gun shot | 10 | MRSA |
| 3. | 43 | Smoker | 3 | Intramedulary nail | 5 | Negative |
| 4. | 58 | Smoker | 6 | Open fracture | 9 | MRSA |
| 5. | 40 | Smoker | 4 | Intramedulary nail | 11 | MRSA |

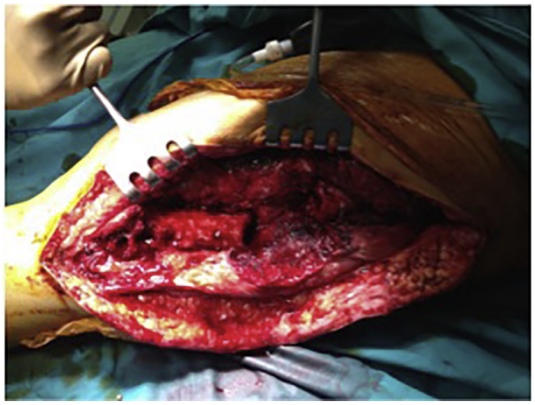

**Fig. 1.** Radical bone and soft tissue debridement after osteomyelitis.

amount of bone resected during the surgery was recorded in centimeters using a sterile ruler.

All patients were men and had an average age of 48.4 (40–61). All patients were smokers (Table 1). One of the patients was in sepsis during operation and acinobacter was isolated in the blood culture. According to Chierny-Mader classification 4 patients were phase IV-A and one patient was IV-B. Osteomyelitis had developed after gunshot injuries in 2 patients, open fracture in one patient, and intramedullary nailing in 2 patients. The average osteomyelitis durations of the patients were 4.7 years (6 months–10 years). The number of the surgeries the patients had had previously was 7.6 (3 − 11). In the culture samples, Methicillin Resistance *Staphylococcus aureus* was isolated in three patients; Acinetobacter Baumannii and *Escherichia coli* in 1 patient. The blood culture of one patient was negative. Three patients had drained sinus openings. One patient, who did not have drained sinus tract and who had negative blood culture, had intraoperative intense purulent fluid.

*Surgical technique*

A stepped surgical treatment was planned for the patients. The patients were operated at supine position under spinal-epidural anesthesia.

In the first step, the osteomyelitis region was accessed via a femoral lateral incision. Present implants were removed. Necrotic

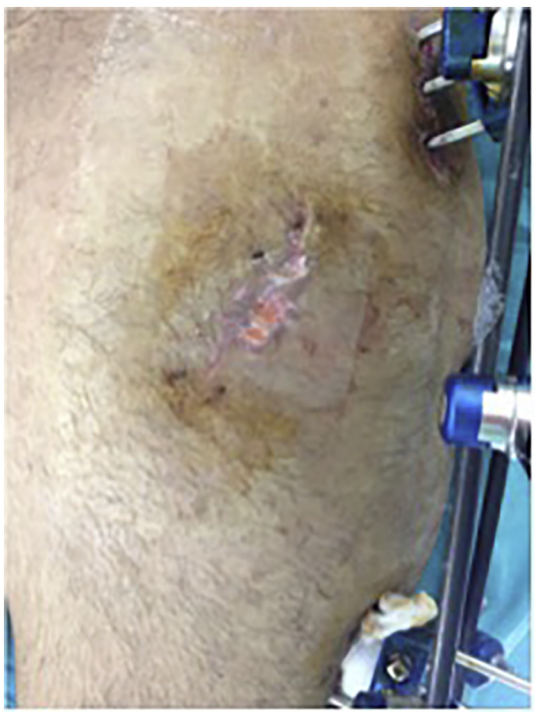

**Fig. 2.** Open sinus tract at the anterolateral thigh.

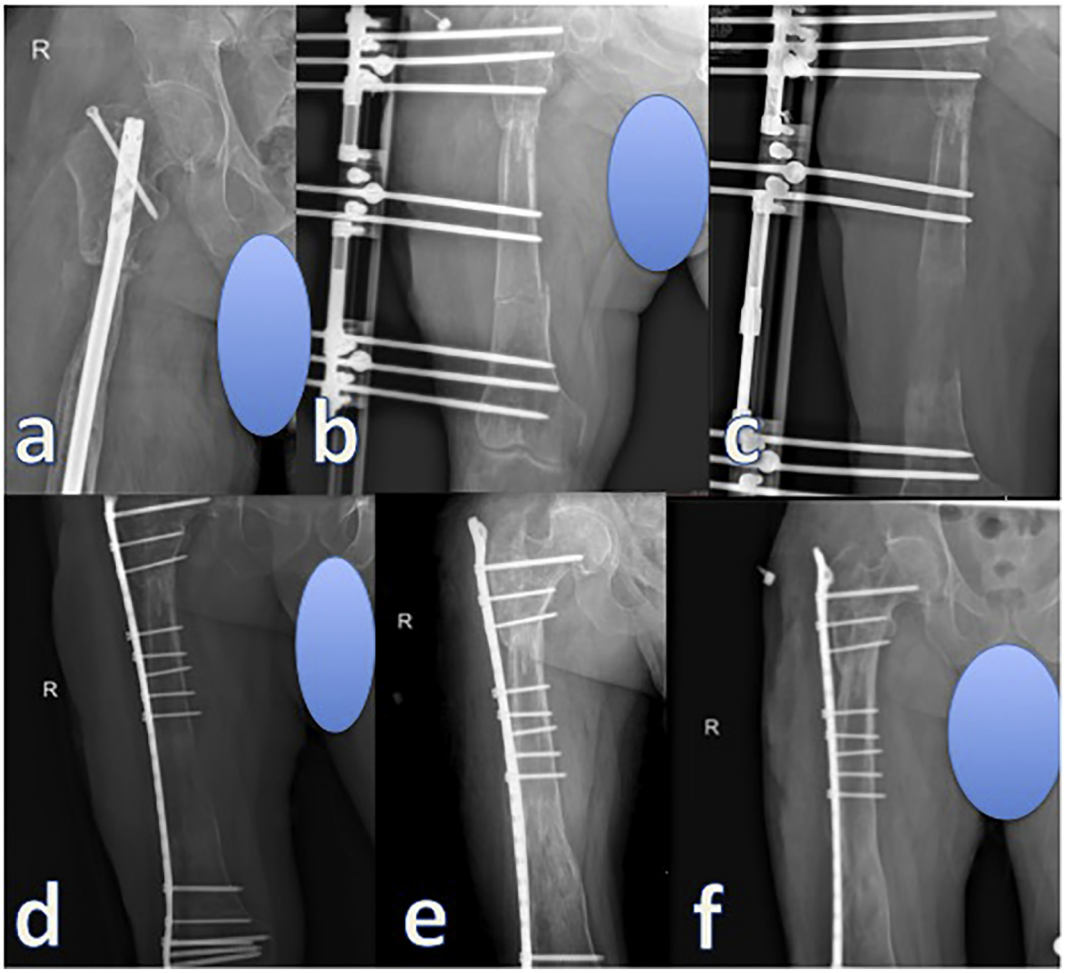


**Fig. 3.** a; femoral defective nonunion after intramedullary nailing. b; nail is removed, infected part of femur is resected. Acute compression is applied with monolateral rail external fixator. Femoral osteotomy close to the metaphysieal area. c; restoration of bone defect with gradual lenghtening. d; external fixator is replaced with a locking plate as an internal fixator, after consolidation is seen at the docking site, early post-operative x ray. e, intermediate control x ray f, final x ray at the last follow up.

bones and infected soft tissues were excised with their sinus tracts(Figs. 1,2). Pathological and microbiological samplings were performed. Bone excision was performed up to the region, where the bone bleed (paprika sign) [10]. Then external fixators were placed. While placing the fixator, the Schanz screws were placed vertical to the femoral shaft at proximal site and parallel to the knee joint at distal site in order to enable lengthening via mechanical axis. For this, 7′ valgus from the distal position was provided to the sliding fixator. Acute compression was performed on the nonunion line in four patients. Segment correction was performed in one patient using the elevator method. Negative pressure drain was placed and the skin was closed. For two or three weeks, the patient had been followed for both laboratory and clinical infection relapse. When there was not any infection relapse, the second step commenced.

In the second step, corticotomy was performed on the femur. Corticotomy was performed with osteotomy after drilling. After seven days, distraction started with one full tour, as half tours two times a day. After obtaining the appropriate bone length, and bone clouding was seen, the patients were taken third operations (Fig. 3).

In the third step, before removing the external fixator placed laterally, the temporary external fixator was placed anteriorly. The Schanz screws of the temporary fixator were placed in a manner to protect both the compression of the nonunion line and the length of the regenerated region. Later, the monolateral external fixator was removed. The skin at the ends of the Schanz screws was removed as a block at the distal and proximal positions. The plate was slid between bone and muscles from these openings at the distal or proximal sites, in accordance with the minimal invasive method and fixed to the bone with all its screws locked. After placing the plate, aoutogenous iliac wing grafting was performed to two patients via these openings. Later the temporary external fixator placed anteriorly was removed (Fig. 4).

After the surgery, the patients were treated with appropriate antibiotics for 6 weeks. The antibiotics were continued as oral maintenance until the removal of the external fixator. For venous thrombosis prophylaxis, 0.4 cc low molecular weight heparin

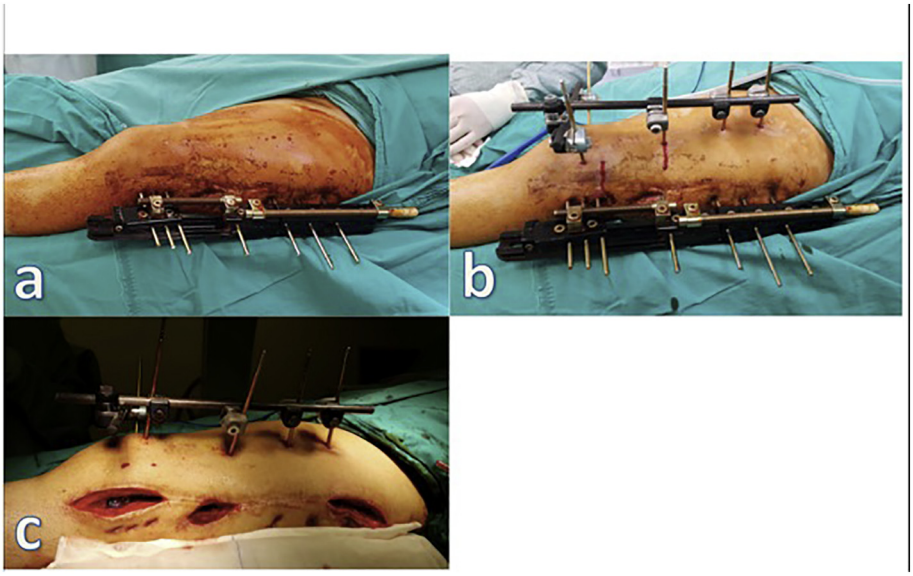


**Fig. 4.** a; monolateral external fixator at the final operation. b; before monolateral external fixator removal, a temporary external fixator is applied to prevent shortening. c; monolateral external fixator is now removed. Pin tracts are excised with debridement. A locking plate is placed form these inscisions in minimal invasively. First one or two screws are placed as compressive way to make plate closer to the bone. And then all of the other screws are placed as locking screws.

(enoxaparin sodium) was applied daily subcutaneously for 1 months after the first surgical intervention. The patients were mobilized with crutches on postoperative first day. Active knee and hip movements were allowed to the extent permitted by the fixator. Towards the end of bone lengthening, weight bearing was allowed with toe tips and touchdown respectively. Full weight bearing was allowed when bone healing was seen at least in three cortical layers.

After the first operation, patients had been followed outpatient for 2 to 3 weeks observing drainage, swelling, eritema, and tenderness. When these symptoms were not seen, the patienst underwent second surgery having osteotomy. Weekly radiographies were examined after osteotomy. After concluding that lengthening was going on properly, monthly radiographies were examined. At the end of the lengthening, bone clouding was expected at the lengthening line. When the clouding was seen, the third step commenced. After the plate implementation, callus formation at the nonunion line was followed with monthly radiographies.

## Results

The Clinical-Radiological assessment was conducted in accordance with the Paley system and ASAMI scoring. The external fixator index was calculated as external fixator duration (day)/amount of lengthening (cm). The consolidation index was calculated as the duration of bone observation at least in three cortical layers at the lengthening line (day)/amount of lengthening. The union at the fracture line was defined as the union and callus tissue formation in thee out of four cortices at the fracture ends.

The average sedimentation rates of the patients before the operation were 63.4 (28–85); the CRP values were 25.8 (21 – 32). These values were 8.6 (5–18) for sedimentation and 2.3 (0–7) for CRP after the operation.

In the radiological examinations of the patients, two patients had preoperative femur angular deformities as varus and 1 patient had as recurvatum. 2 patients did not have angular deformities. The average preoperative shortening was 5.4 cm (0–140). An average of 6.34 cm (2.0–13.7) bone resection was implemented. The average of bone defects after debridement was 11.34 cm (7.0–19.0). An average of 10.28 cm (6.0–17.4) lengthening was performed. The average shortening at the end of lengthening was 1.6 cm (0–2.5). The average external fixator index was 15.27 day/cm (6.9–24), and the average consolidation index was 48.73 day/cm (32–77.14). In the postoperative controls, all angular deformities were corrected and additional deformities were not present. The average

**Table 2**
Bone defect status. (f.d.a.f; femoral defect at first(cm), b.r.; bone resection(cm), t.d.; total defect(cm), a.e.; amount of elongation(cm), s.e.; shortening at the end(cm), follow up (months).

| Patient no | f.d.a.f. | b.r. | t.d. | a.e. | s.a.e. | follow up |
|---|---|---|---|---|---|---|
| 1 | 0 | 137 | 137 | 137 | 0 | 24 |
| 2 | 140 | 50 | 190 | 174 | 20 | 48 |
| 3 | 40 | 30 | 70 | 60 | 15 | 48 |
| 4 | 40 | 50 | 70 | 70 | 20 | 60 |
| 5 | 50 | 50 | 100 | 75 | 25 | 12 |

**Table 3**
Bone healing status. (e.f.T; external fixation time(months), c.T.; consolidation time(months), union time(months), e.f.i.(external fixator index), c.i. (consalidation index).

| Patient no | e.f. T | c. T | union time | e.f.i.(day/cm) | c.i.(day/cm) |
|---|---|---|---|---|---|
| 1 | 6 | 8 | 18 | 13,33 | 40,00 |
| 2 | 4 | 8 | 20 | 6,90 | 34,48 |
| 3 | 3 | 4 | 12 | 15,00 | 60,00 |
| 4 | 4 | 6 | 18 | 17,14 | 77,14 |
| 5 | 6 | 6 | 8 | 24,00 | 32,00 |

duration of union was 15.2 months (8–20) (Tables 2 and 3).

The patients had been followed for an average of 38.4 months (12–60). Union was obtained in all patients (Figs. 5,6). One patient had implant failure. This patient was treated with grafting and double plate fixation. All patients had pin tract infection and all were able to be treated with antibiotics. In one patient, early plate removal was performed due to difficulty of controlling the pin tract

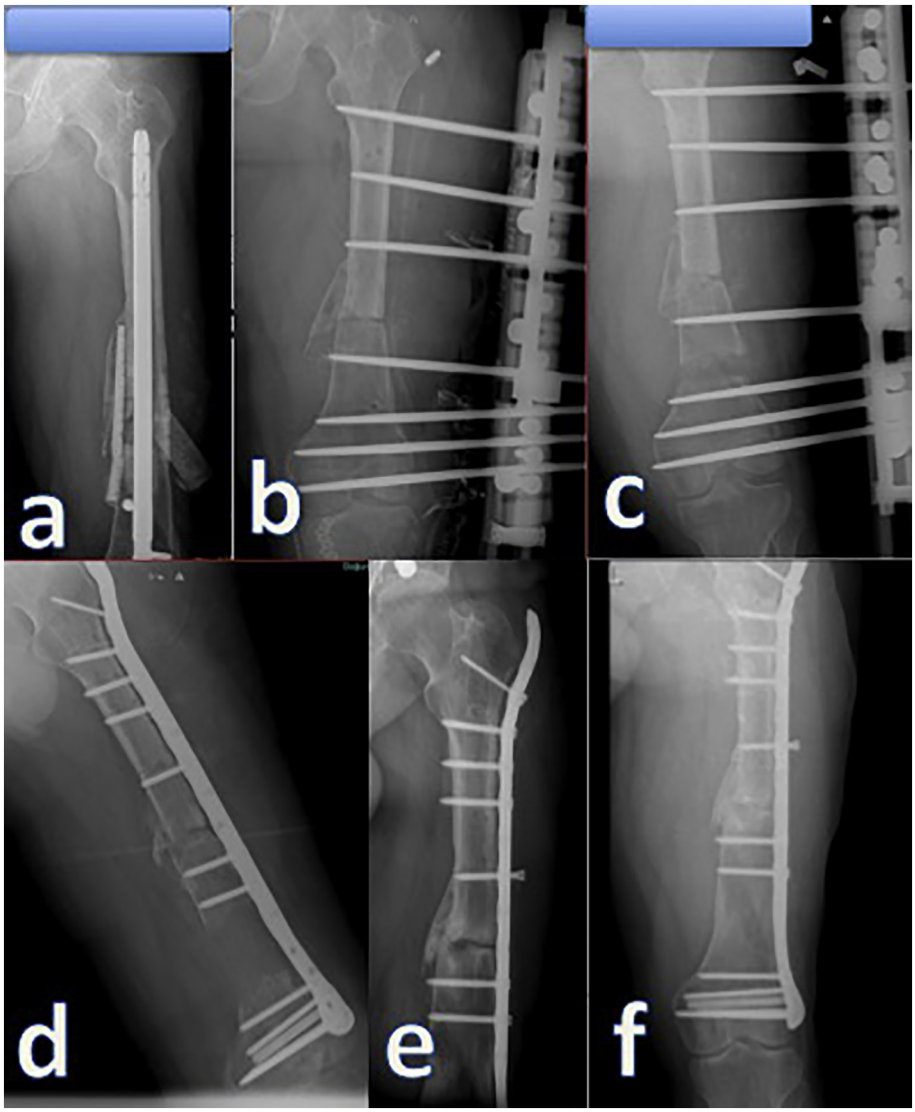


**Fig. 5.** a, femoral defective nonunion after intramedullary nailing. b,removal of nail, femoral bone resection of infected bone. Acute compression with monolateral rail external fixator. Femoral osteotomy close to the metaphysieal area. c; restoration of bone defect with gradual lenghtening. d; after consolidation seen at the docking site, external fixator is replaced with a locking plate as an internal fixator, early postoperative x ray. e, intermediate control x ray f, final x ray at the last follow up.

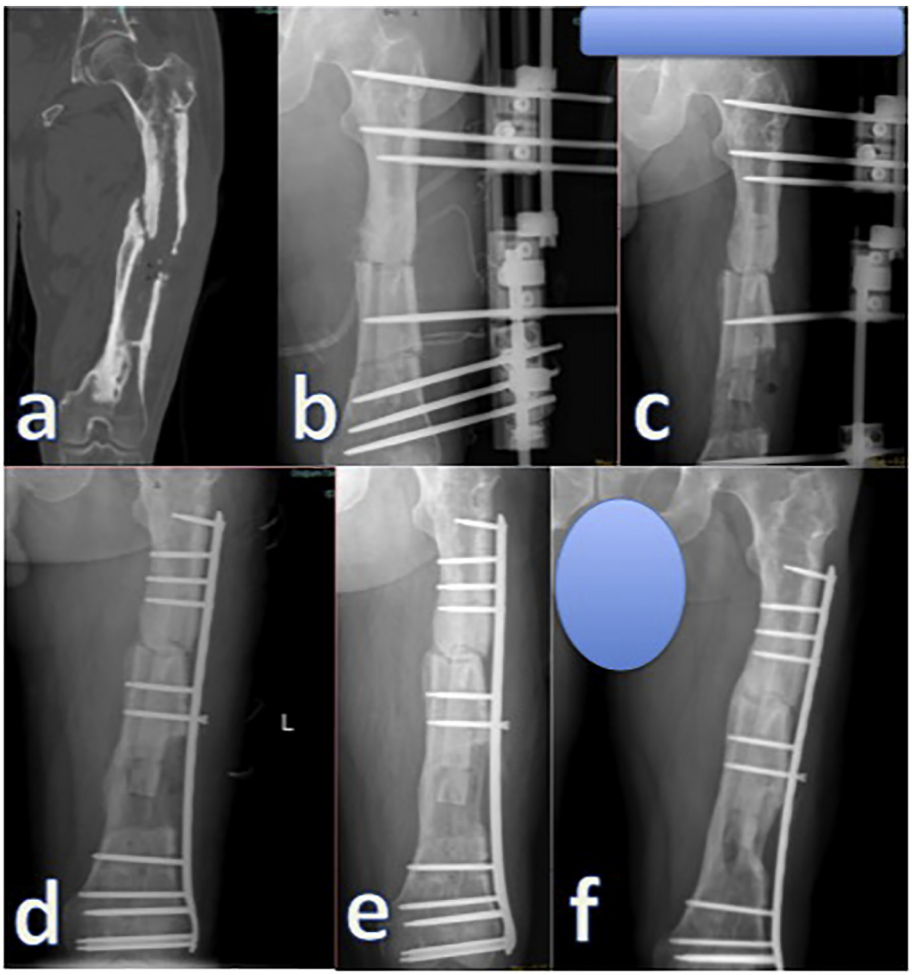


**Fig. 6.** a, femoral defective nonunion. b,removal of nail, femoral bone resection of infected bone. Acute compression preformed with monolateral rail external fixator. Femoral osteotomy performed close to the metaphysieal area. c; restoration of bone defect is seen with gradual lenghtening. d; after consolidation is seen at the docking site, replacement of external fixator with a locking plate as an internal fixator, early postoperative x ray. e, intermediate control x ray f, final x ray at the last follow up.

infection. None of the patients experienced infection relapse. All patients had knee flexion limitation in early period. However, it was seen, in the clinical follow-up, that the knee flexion degrees increased. The average knee flexion angles were 86′ (60′-120′).

The clinical Paley/ASAMI score was perfect in one patient, and good in 4 patients. Bone Paley/ASAMI score was perfect in 4 patients and good in one patient. Bone scores were better than the clinic scores (Table 4).

## Discussion

Femur is the longest bone of the body; in which shortening is less tolerated. And also it is the bone with the longest duration needed for union. Defected, infected femur nonunion is one of the most difficult situations of orthopedics. There are three conditions, each of which is difficult to treat even existing alone; (1) infection, (2) shortening/deformity and (3) nonunion. A staged treatment

**Table 4**
ASAMİ criteria, bone and functional status and complication classification.

| Patient no | ASAMİ bone | ASAMİ clinic | Knee flexion | Knee extension loss | Paley 1 | Paley 2 | Paley 3 |
|---|---|---|---|---|---|---|---|
| 1 | Excellent | Good | 90 | 0 | Pin tract, | Second look debridement | None |
| 2 | Good | Good | 70 | 5 | Pin tract, | None | Implant failure |
| 3 | Excellent | Good | 90 | 0 | Pin tract, | None | None |
| 4 | Excellent | Excellent | 120 | 0 | pin tract, | None | None |
| 5 | Excellent | Good | 60 | 0 | pin tract, | None | None |

would be reasonable in the treatment of all these three conditions [11].The first and the most important step is the eradication of the infection. Infection is the most important reason for shortening due to nonunion and bone necrosis. Infection treatment could be performed via wide debridement surgically and with help of antibiotherapy. Later lengthening (distraction osteogenesis) and more stable fixation of the fracture should be done.

In the reperation of segmental bone defects, bone grafting and MAsQUET technique were also defined. The use of Iliac bone grafting and staged grafting with MAsQUET technique is not recommended in defects larger than 2 cm. Problems such as foreign body infection, graft osteolysis, infection relapse, mechanic deficiencies in the graft could be seen in these patients [12]. Using fibula as graft is also restrained for defects in femur; cause fibula has a smaller diameter than the femur and it allows a limited amount of lengthening [13].

Ilizarov technique is also used in the treatment of the infected defective femur pseudoarthrosis. With Ilizarov technique, it is possible to perform debridement, stabile fixation, and defect reconstruction using corticotomy [5]. Monolateral fixators are also used instead of the Ilizarov technique due to complicated implementation. Corticotomy increases blood flow to the bone and thus has union stimulating effect. However, due to infection and multiple surgeries experienced before, time needed for fracture union and regenerate formation could be very long. The external fixator duration in defective nonunion treated with Ilizarov technique and monolateral external fixator, varies between 10 months and 23.4 months. Although studies over treatment with external fixators show good outcomes, prolonged external fixation is hard to tolarate for the patients [14,15]. In order to shorten external fixation duration different methods were described; like combined treatments of external fixators with intramedullary nails or plates.

For treatment of defected femoral nonunions; intramedullary nails are used with external fixator together and in a staged manner. Intramedullary nail fixation is more rigid than the plate fixation. But multiple surgeries lead to insufficient periosteal circulation, in addition intramedullary nailing may disturb endosteal circulation and the regeneration of the bone may be difficult. There is also risk of spreading of infection all over the femur and the case may be more complicated [16]. Moreover, in this technique the nails require additional holes, differently from conventional nails. This, in turn, requires custom made nails. Another problem in intramedullary nail implementation is the difficulty in placing the nail in some patients due to angular changes and deformities caused by osteomyelitis. However, plates could be placed in all forms of bones Kocaoğlu and Eralp reported successfull defect restoration via wide debridement and subsequent infection eradication, following an intramedullary nail. They shortened the external fixator duration (4–6 months). In addition, problems such as re-fracture after removing fixator, angling, development of shortening were not present. However, two of their patients had infection and they made revision again with the Ilizarov technique.

Another technique described in treatment of defected femoral nonunions is plate fixation with lenghtening after external fixation. Bone lengthening using plate had become popular with Wagner [17]. However, it lost its popularity due to problems in acute lengthening [18].For a long time, bone lengthening had been performed using external fixators. Different incentives have been tried recently to reduce the external fixator duration. Bone lengthening using plates are preferred especially in cases who are not suitable for nails and patients with open physis [19].

Plate use in femur osteomyelitis treatment is a relatively new implementation. In a case report published in 2002, bone defect very close to the joint was reconstructed in staged procedure using a plate and external fixator combination [20]. Later, in two studies in 2015 and 2017, staged surgeries were performed also with fixator and plate. In the first step defect close to the joint caused by osteomyelitis was fixed with plate and then the defect was reconstructed [21,22]. In these three studies, the number of previous surgeries are fewer (0–1) and infection durations are shorter (0–6 months) and the patients are younger (17-25Shoutao Zhang et al. presented their cases with defected femur and tibia. After the reparation of the defect with external fixation, they placed a plate to the docking site in their treatment [23]. This study included 3 femur patients. Short plates that did not reach the lengthening line were preferred. In comparison to the patients, who were treated completely with external fixator, they found better union and shorter external fixator duration in their cases.

In our study, the average number of previous surgeries was 7.6, and the average infection duration was 4.7 years. The defect sizes are similar both in our study and the other studies using plates (11.3 cm in our study; 7-11 cm in others). In our technique, we planned, from the very beginning, both fracture union and segment transfer using an external fixator, and later we removed the external fixator and implemented plates instead as internal fixator. The external fixator duration was between 4 and 6 months. After closing the defect using monolateral fixator, the minimal invasive locked plate implementation shortened the external fixator duration.

The use of temporary external fixator both prevented the distraction at the fracture line that could emerge during surgery, and the shortening at the regenerate region. Temporary external fixators are used to preserve reduction and length in primary fracture treatment, arthrodesis and in cases where stepped surgery is applied [24]. By using temporary fixators, placing the sliding plate using minimal invasive technique was easier and safer.

In our technique, infection relapse was not experienced. The reason for this is the possibility of wide debridement and plate implementation following lengthening causing less damage to the bone and soft tissue. Obtaining union in all patients could be explained with the treatment of the infection and undisturbed femur blood flow. The bone defect following debridement could be reconstructed. Since the plate implementation had been performed using minimal invasive method, relatively less harm was given to the bone biology. The endosteal circulation was preserved. Both the reduction and the length were preserved with the use of temporary external fixator during plate implementation. In addition, the locking plate did not require a custom made production.

All patients experienced pin track infections as the complication. The pin track infection was superficial in 4 patients. In one patient we couldn't control pin track infection. We could not perform further lengthening and the patient had residual shortening. In one patient the plate was broken. We treated this patient with fixation with double plate and grafting at the lengthening site. All patients had limitations of Range of Motions of knee joints. Although begining early knee mobilisation exercise, we could not prevent

this situation. This issue is reported as a problem in all other publications.

## Conclusions

The limitations of our study are being a retrospective study and having a few number of patients. However, conducting a retrospective study on femur osteomyelitis is quite difficult. In addition, in the osteomyelitis studies in the literature, most of the patients had tibia osteomyelitis and the number of the patients, on which the defect restoration had been conducted is very few. In order to evaluate the efficacy of our method better, longer follow-ups with more patients are needed. Larger series will obviously be more informative and will have more definitive results. Another issue is that all of the patients were male. Gender differences could have different effects on bone recovery [25]. Therefore, the results of our study could not be generalized. The majority of the patients in the femur osteomyelitis studies in the literature are male.

The sterilization techniques and effective antibiotics treatment have made progress recently to both prevent and treat infection. However, individual armament and wars have progressed similarly. Therefore, even though it is not frequent as before, osteomyelitis would continue to be a major issue for surgeons. For this reason, osteomyelitis treatment requires new surgical techniques and different perspectives.

## Author contribution

Mehmet Akdemir: Writing - original draft
Çağdaş Biçen: Methodology, Writing - review & editing
Mehmet Aykut Türken: Investigation
Ahmet Cemil Turan: Data collection
Alper Arıkan: Data collection

## Declaration of competing interest

All authors disclose any financial and personal relationships with other people or organisations that could inappropriately influence (bias) their work.

Mehmet Akdemir, Çağdaş Biçen, Mehmet Aykut Türken, Ahmet Cemil Turan, Alper Arıkan.

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