

External fixation of complex femoral shaft fractures

M. Zlowodzki · J. S. Prakash · N. K. Aggarwal

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Abstract Conversion of temporary external fixation to an intramedullary nail within the first 2 weeks after a femoral shaft fracture is standard practice. However, due to financial constraints, in large parts of the world external fixation of femoral shaft fractures is often the definitive treatment. Out of 60 fractures, 47 were followed-up for a minimum period of 39 weeks. The average follow-up time was 75 weeks. Fourteen fractures were closed, and 33 open. Forty-four fractures united at an average of 31 weeks. There were four non-unions, three of them infected. Secondary surgical procedures were performed for four non-unions and in eight cases of delayed union. One re-fracture occurred, which was successfully treated with repeat external fixation. Only six patients regained full range of motion. The average flexion was 72°. Pin tract infections occurred in 26 patients, leading to loosening of four pins. Satisfactory results can be obtained with definitive external fixation of femoral shaft fractures. Pin tract infections, although a common occurrence, are not a major problem and can be treated by local wound care and antibiotic therapy. The most common

problem is significant decrease in the range of motion of the knee.

Résumé Le traitement par fixation externe temporaire et conversion secondaire par un clou centro médullaire dans les 15 premières jours après fracture de la diaphyse fémorale est une technique standard. Cependant du fait des contraintes financières, le traitement par fixation externe est le plus souvent un traitement définitif. 47 fractures sur 60 ont été suivies avec un minimum de 39 semaines. Le temps moyen de suivi a été de 75 semaines. 14 fractures étaient fermées et 33 ouvertes. 44 fractures ont consolidé avec un temps moyen de 31 semaines. Cette étude met en évidence 4 pseudarthroses, 4 retards de consolidation dont 3 infectées. Un traitement chirurgical a été réalisé dans tous les cas. Nous avons observé une récurrence de fracture qui a été traitée avec succès par la mise en place d'un nouveau fixateur externe. Seulement 6 patients ont retrouvé une mobilité complète du genou. La flexion moyenne a été de 72 degrés. Une infection sur le trajet des broches est intervenue chez 36 patients entraînant la mobilisation de 4 broches. Un résultat satisfaisant peut être obtenu par le traitement par fixation externe définitif des fractures de la diaphyse fémorale. La survenue d'infection sur le trajet des broches n'est pas un problème important et peut être traité localement par antibio thérapie ou soins locaux. Le problème principal est la diminution de la mobilité du genou survenant après ces fractures.

M. Zlowodzki (✉)
University of Minnesota, Department of Orthopaedic Surgery,
Regions Hospital,
640 Jackson Street, Mail Stop11503L,
St. Paul, MN 55101, USA
e-mail: Zlowi@web.de

J. S. Prakash
Department of Orthopaedic Surgery, Christian Medical College,
Ludhiana (Pb.), India

N. K. Aggarwal
Institute of Orthopaedics and Super Specialty Trauma Centre,
Gurdev Hospital,
Ludhiana (Pb.), India

Introduction

Intramedullary nailing is considered to be the treatment of choice for stabilisation of most femoral shaft fractures [17]. However, there are situations where primary intramedullary

nailing could be unsuitable, such as severe open fractures, extensive soft tissue damage, and when the patient's general condition precludes major surgery. Often, in these situations, external fixation is used for temporary fixation. Conversion to an intramedullary nail within one to two weeks of the injury is standard practice [11]; however, due to financial constraints, in large parts of the world external fixation of femoral shaft fractures is often the definitive treatment.

Evidence regarding definitive treatment of femoral shaft fractures with external fixation is limited and based on small case series only. [2–7, 9, 10, 12, 13, 15] The purpose of this paper is to present a larger case series and give guidelines for treatment of femoral fracture by external fixation based on the senior author's experience.

Material and methods

Fifty-eight patients with 60 femoral fractures seen between July 1989 and July 1994 were treated at the Christian Medical College and Hospital in Ludhiana, India, with an external fixation device. Forty-five patients with 47 fractures were followed-up for a minimum period of 39 weeks (9 months) or until bone union. The average follow-up time was 75 weeks (range 10–248 weeks). Three patients died for reasons unrelated to the fracture, i.e., cardiopulmonary arrest, septicaemia, and ethanol intoxication, respectively. Another ten patients were either lost to follow-up or had inadequate follow-up.

The average age of the patients was 33.2 ± 11.4 years (range 6 years to 55 years). There were 42 men and three women. In 28 cases the right femur was involved, and in 19 cases the left femur. Two patients had a bilateral femur fracture. In 12 cases the fracture was located in the proximal third of the femur, in 15 cases in the middle third of the femur and in 20 cases in the distal third. Fourteen fractures were closed, and 33 open (Table 1). The mechanisms of injury were motor vehicle accidents (43 fractures in 41 patients) and gun shot injuries (four fractures).

In seven cases the fixation was carried out in the first 24 h, in two cases within 48 h and in two cases within 72 h of the injury. In the remaining 36 cases the average delay was 17.3 days.

The following types of external fixators were used:

- AO (35 cases)
- Custom fixator (eight cases) [1, 16]
- Hoffmann (two cases)
- Ilizarov (two cases)

Table 1 Outcome in relation to fracture type (open/closed)

Fracture type	Number	Union	Delayed union	Non-union (uninfected)	Non-union (infected)
Closed	14	8	5	1	–
Open: I	3	3	–	–	–
Open: II	5	4	1	–	–
Open: IIIA	–	–	–	–	–
Open: IIIB	24	17	4	–	3
Open: IIIC	1	–	1	–	–
Total	47	32	11	1	3

Forty-five fractures were acute. Secondary external fixation with an Ilizarov-type ring fixator was performed in a case of a delayed union and in another case of an infected gap non-union. Initial bone grafting was done when significant bone loss was present and in cases of non-union or delayed union ($n=6$).

The external fixator was removed in the first 12 cases when radiographic signs of healing were seen (union of three out of four cortices). In the following cases the fixator was removed in stages, starting with appearance of early callus. It was removed completely after sufficient callus was seen at an average of 18.3 weeks (range 3–125 weeks). External support after complete removal of fixator was used in the form of a single spica cast or a PVC thigh lacer for six to eight weeks in all cases.

The patients were mobilised with crutches as soon as possible, first non-weight bearing, and then gradually increased weight bearing within tolerable limits of pain. Patient compliance for early ambulation was greater with our custom fixator, possibly because of its light aluminum alloy frame.

Bone union was evaluated clinically and radiographically, according to common criteria in the literature. Fractures were considered to be united clinically in the absence of movement and pain on stress at the fracture site. Radiographic union was achieved in the presence of uniform and continuous ossification of callus, with consolidation and development of trabeculae across the fracture site. [8] Union time of more than 26 weeks in closed fractures and 39 weeks in open fractures was considered to be a delayed union. [9, 14, 15] The diagnosis of non-union was made in the presence of abnormal movement at the fracture site at least 9 months after the injury and with no progressive signs of healing for at least 3 months, despite continuing treatment. [14] We defined malunion if one of the following criteria was met: shortening of more than 2.5 cm, angula-

tion of more than 10°, or rotational malalignment of more than 5°.

Results

Forty-three fractures, including 11 delayed unions, united at an average of 31 weeks (range 10–115 weeks). (Table 2) Excluding the delayed unions, 32 fractures united uneventfully at an average time of 26 weeks (range 10–29 weeks). Eleven fractures had delayed union, with an average union time of 49 weeks (range 27–115 weeks). Five of these occurred in closed fractures and six in open fractures. All delayed unions were severely comminuted fractures with or without bone loss in multiply injured patients. In four cases there was bone loss of 5 cm or more. Weight bearing was delayed in these cases, because of associated injuries to the lower and upper extremities.

Secondary surgical procedures were performed in eight cases of delayed union:

- Four corticocancellous grafts (22 weeks to 24 weeks after injury)
- Three sequential bone marrow graftings (20 weeks to 24 weeks after injury)
- One fibular graft (at 22 weeks)
- One application of ring fixator (23 weeks after injury)
- The other three cases united without any additional procedure.

There were four non-unions. One of them was a closed segmental fracture. The other three were all IIIB open fractures that became infected during the course of treatment. One patient developed chronic osteomyelitis requiring an above-knee amputation. One fracture healed after surgical debridement and application of a ring fixator, and one fracture healed after removal of the external fixator and subsequent traction for 3 months.

Malunion occurred in six cases: two shortenings of 3 cm, two varus deformities of 10° to 20°, one recurvatum deformity, and one internal rotation deformity of 20°. Also, one re-fracture occurred, which was successfully treated with repeat external fixation. Loss of reduction after

external fixation was observed in nine cases. The fractures were realigned in all these cases.

A major complication was a decrease in the range of motion of the knee joint. Only six patients regained full range of motion. The average flexion was 72°. In 23 patients the knee flexion was less than 60°. In 11 of these the fracture was located in the distal third of the femur. The rest had either severe soft tissue crushing, ipsilateral leg injury or had multiple associated injuries. Two fractures had an intra-articular extension. The fixator was applied across the knee joint in four cases. In two patients there was an extension lag of 10° and 15°, respectively. Two patients also had restricted hip motion (0° to 90°).

Pin problems were frequently encountered but did not influence the outcome. Pin tract infections occurred in 26 patients, leading to loosening of four pins. The overall rate of infection from inserted Schanz screws was 15.8%. This was managed successfully by debridement and removal and re-insertion of the Schanz screws. Three abscesses were treated by drainage, debridement and intravenous administration of antibiotics. Other minor complications were cellulitis (two cases) and breakage of Schanz screws during insertion (three cases).

Discussion

Treatment options for open femoral shaft fractures include primary intramedullary nailing, plating and external fixation. If external fixation is performed, it is usual to convert the external fixation to intramedullary nailing, usually within 2 weeks of the injury. Nowotarski et al. reported one infected non-union and one non-infected non-union with hardware failure in 19 patients with open femoral shaft fractures, and no complication in 39 closed fractures treated with temporary external fixation that had been converted to an intramedullary nail as definitive treatment after an average of 7 days [11]. Alonso et al. reported three pin tract infections and one case of osteomyelitis out of six cases of temporary external fixation with subsequent intramedullary nailing [2].

Although external fixation is not the method of choice for definitive treatment of femoral shaft fractures, in some countries it is the cheapest option and, therefore, is widely used. Our study shows that, if no conversion to intramedullary nailing is performed, definitive external fixation of femoral shaft fractures yields reasonable results. In this series the non-union rate was 8.5% (3/4 infected).

Those findings are comparable to reported data in the literature. De Bastiani et al. reported healing rates of 98% in closed femoral fractures and 89% in open femoral fractures, when external fixation was used as definitive treatment [6].

Table 2 Average union time (includes 11 delayed unions). In four patients union was not achieved

Fracture type	Number	Average time (weeks)	Range (weeks)
Closed	13	25	13–42
Open: I	3	26	17–32
Open: II	5	27	18–42
Open: IIIB/C	22	36	13–115
Total	43	31	13–115

The reported union rates for external fixation of femoral shaft fractures in series with significant numbers of open fractures range between 70% and 100% [3, 5, 7, 10, 12, 15]. Barquet et al. reported three secondary surgical procedures for two infected and one uninfected non-union in their series of 14 open fractures [3]. Murphy et al. performed four secondary intramedullary nailings for failed treatment with external fixation, due to three delayed unions and one recurrent valgus deformation in a series of 26 open and six closed fractures [10]. Titius et al. reported a union rate of 100% in a series of 20 open and six closed fractures. There were four malunions that were treated by exchange external fixation [15]. In a series of 13 open and seven closed fractures Dabezies et al. reported no infections and one secondary intramedullary nailing due to recurrent valgus deformity [5]. Rooser et al. reported a union rate of 87% in a series of five open and ten closed fractures, while comminution was present in 12 fractures. There was one infection and another non-union [12]. Gottschalk et al. performed external fixation for three open and four closed comminuted fractures, which had a union rate of 100% [7]. Coppola and Anzel reported three non-unions in a series of 21 fractures, some of them having been open [5]. The reported average time-to-healing ranges of between 3 months and 7.5 months [3–5, 7, 10, 12, 15]. In this series the average time to healing was 7.2 months. Most of the authors applied some form of after-support, e.g., braces, spica casts or long leg casts after removal of the external fixator for approximately 3 months to 7 months [3, 5, 10, 12].

Common complications after external fixation of femoral fractures are pin tract infections and decreased range of motion of the knee joint. The reported rates of pin tract infections range between 7% and 57% [3–5, 7, 10, 12, 15]. Most of them were not a significant problem. Only in some cases did pin tract infections lead to earlier removal of the external fixator [4, 5, 10]. In this series the overall pin infection rate was 15.8%. This was managed successfully by debridement and re-insertion of the Schanz screws. Three abscesses were treated by drainage, debridement and intravenous administration of antibiotics.

Decreased range of motion of the knee joint can be significant after external fixation of femoral shaft fractures, especially when the external fixator is applied across the knee. Murphy et al. reported an average flexion of 91°, with 44% of patients achieving less than 90° [10]. Dabezies et al. reported full range of motion in 50% of their patients, the other 50% having an average loss of flexion of 50° [5]. Barquet et al. reported a loss of extension of less than 5° and a minimum amount of flexion of 90°, with a mean of 120° occurring in 64% of their patients. Loss of extension of more than 5° and a range of flexion between 60° and 90° was found in 28% of the patients [3]. In this series only six

patients regained full range of motion. The average flexion was 72°. In 23 patients the knee flexion was less than 60°.

Conclusion

Satisfactory results can be obtained with definitive external fixation of femoral shaft fractures if stable fixation is achieved. It gives predictable results with an acceptable complication rate in selected complex and/or severe open fractures of the femur. A strict postoperative protocol, including early ambulation, physical therapy, staged removal of the fixator and protection of the bone after complete removal, needs to be followed. Pin tract infections, although a common occurrence, are not a major problem and can be treated by local wound care and antibiotic therapy. The most common problem of external fixation of femoral shaft fractures remains the decrease in the range of motion of the knee, especially for fractures around the knee and when the external fixator is applied across the knee joint.

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