

Results of open tibial fracture treatment using external fixation

Ivan Golubović¹, Branko Ristić², Predrag Stojiljković¹, Milan Ćirić³, Ivana Golubović⁴, Zoran Radovanović⁵, Sladjana Petrović⁵, Nina Djordjević¹, Zoran Golubović¹, Stevo Najman⁶

¹Clinical Center Niš, Clinic for Orthopedics and Traumatology, Niš, Serbia;

²Clinical Center Kragujevac, Clinic for Orthopedics and Traumatology, Kragujevac, Serbia;

³University of Niš, Faculty of Medicine, Institute of Physiology, Niš, Serbia;

⁴University of Niš, Faculty of Medicine, Niš, Serbia;

⁵Clinical Center Niš, Institute of Radiology, Niš, Serbia;

⁶University of Niš, Faculty of Medicine, Institute of Biology and Human Genetics, Niš, Serbia

SUMMARY

Introduction Open lower leg fractures are the most common open fractures of the locomotor system and their treatment is associated with a number of complications.

Objective The aim of the paper was to present the results of the treatment of 68 patients with open lower leg fractures, as well as the complications that accompany the treatment of these fractures.

Methods In the analyzed group, there were 45 (66.18%) men and 23 (33.82%) women. The majority of patients – 33 (48.53%) of them – were injured in motor vehicle accidents, whereas 24 (35.29%) patients sustained injuries due to falls from heights. In two (2.94%) patients the cause of open tibial fractures was gunshot injuries. In the analyzed group, there were 18 (26.47%) type I open fractures, 21 (30.88%) type II open fractures, 19 (27.94%) type IIIA open fractures, seven (10.29%) type IIIB open fractures, and three (4.41%) type IIIC open fractures.

Results The tibial shaft fracture healed without serious complications in 50 (73.53%) patients, whereas in 18 (26.47%) patients we observed some complications. Nonunion was found in 10 (14.71%) patients, osteitis in four (5.88), malunion in two (2.94%) patients. Milder complications such as soft tissue pin tract infection developed in 13 (19.12%) patients, infection of the open fracture wound soft tissue was observed in four (5.88%) patients.

Conclusion Basic principles in the treatment of open lower leg fractures in this study are thorough primary open fracture wound treatment followed by the delayed wound closure, stable fracture fixation using unilateral external skeletal device, proper antibiotic treatment and tetanus prophylaxis. The results correlate with similar studies.

Keywords: open lower leg fractures; treatment; external skeletal fixation; postoperative complications

INTRODUCTION

Open lower leg fractures are the most common open fractures and account for 63% of all open fractures of the locomotor system [1]. As high energy traumas, they are usually the result of a motor vehicle accident [2].

Treatment of open lower leg fractures involves the primary management of an open fracture wound, fracture fixation, antibiotic therapy, tetanus prophylaxis, and delayed wound closure. One of the most important procedures in fighting infection is the primary surgical management of the open fracture wound, followed by the removal of avital tissues from the wound, i.e. wound debridement. Primary management of the open fracture wound is an important factor for the prevention of both aerobic and anaerobic infections (osteitis, gas gangrene, and tetanus) [3]. Treatment of open lower leg fractures includes a number of complications, such as infection of the open fracture wound, deep bone infection (osteitis), delayed healing, malunion, nonunion, and loss of extremity. The aim of the treatment of open tibial fractures was to ensure healing and pro-

mote restoration of the injured extremity function, which enables patients to return to their work activities and daily routines [4].

In modern traumatology, there is still a debate on the choice of the open tibial fracture fixation method and surgical management of damaged sheaths of the lower leg soft tissue [5, 6].

OBJECTIVE

The aim of the paper was to present the results of the treatment of 68 patients with open lower leg fractures using external skeletal fixation. The patients were treated during a four-year period at the Clinic of Orthopedics and Traumatology, Clinical Center Niš, Serbia.

METHODS

The results of the treatment of 68 patients with open lower leg fractures have been analyzed. The patients were treated at the Clinic of Orthopedics and Traumatology, Clinical Center Niš, from January 1, 2005, until January 1,

Correspondence to:

Zoran GOLUBOVIĆ
Clinic for Orthopedics and
Traumatology
Clinical Center Niš
Bulevar dr Zorana Djindjića 48,
18000 Niš
Serbia
doktorzorangolubovic@gmail.com

2009. After surgical care, the patients were followed up for 16–24 months.

In the analyzed group there were 45 (66.18%) men and 23 (33.82%) women. The youngest patient was 14, and the oldest 82 years of age. The mean age of patients was 46.7 years.

Analyzing the etiology of injury, we found that the majority of patients – 33 (48.53%) of them – were injured in motor vehicle accidents, whereas 24 (35.29%) patients sustained injuries due to falls from heights. In the analyzed group, seven (10.29%) patients sustained agricultural injuries (timber falls, tractor overturns, etc.), two (2.94%) patients sustained sports injuries, whereas two (2.94%) sustained gunshot injuries.

For the staging of open fractures, Gustilo classification, introduced in 1976 and subsequently modified in 1984, was used [7].

In the analyzed group, there were 18 (26.47%) type I open fractures, 21 (30.88%) type II open fractures, 19 (27.94%) type IIIA open fractures, seven (10.29%) type IIIB open fractures, and three (4.41%) type IIIC open fractures.

With regard to the type of injury, an isolated injury of the tibial shaft was found in 38 (55.88%) patients, whereas 30 (43.22%) patients had multiple injuries, including the open lower leg injury.

The treatment of patients with open tibial fractures included profuse irrigation and primary management of

the open fracture wound, followed by the reposition of bone fragments and external skeletal fixation using the Mitkovic external skeletal fixator, an original unilateral device (Figures 1–5). The open fracture wound was left open and delayed wound closure was performed (by primary wound closure, secondary closure, or some of the plastic surgery methods used for the management of soft tissue defects) (Figure 6). Primary amputation was performed in two patients, one of whom had a comminuted fracture as he had been run over by a truck, whereas forefoot amputation was performed in another patient previously injured by a roller. Tibial shaft fracture was treated by external skeletal fixation.

In patients with open tibial fractures, antibiotic therapy was administered. Regularly, the combination of the 3rd- and 4th-generation cephalosporins and aminoglycoside (amikacin) was administered as a first step. In type I and II open fractures, antibiotic therapy is continued 48–76 hours after sustaining an injury, and in type III fractures it can be administered up to 120 hours after sustaining an injury and performing primary debridement [8]. Anti-tetanus prophylaxis is given to all patients with open fracture, according to the protocol.

In heavily contaminated wounds, especially with soil, there is a risk of serious infection caused by anaerobic bacteria, the cause of gas gangrene. In these cases, besides the regular antibiotics combination, metronidazole and clindamycin were administered.



Figure 1. An open fracture in the distal lower leg (A) and extensive soft tissue injury (B)

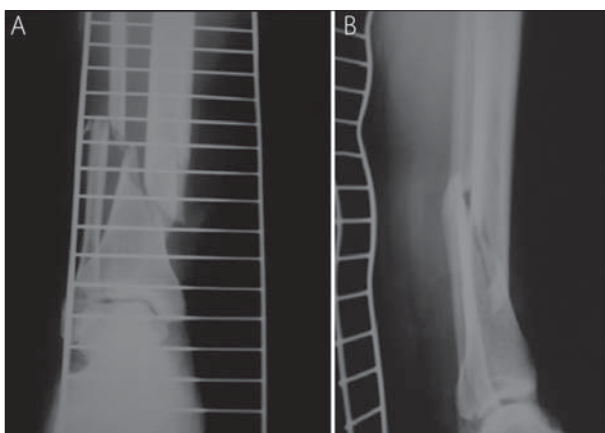


Figure 2. The antero-posterior (A) and lateral (B) X-rays demonstrate spiral fractures in the distal tibial and fibular shaft with dislocation of fragments



Figure 3. Upon admission, after short preoperative preparation, the following procedures were performed: operative treatment, management of the open fracture wound, reposition of fragments, and fracture stabilization using an external skeletal fixator. The open fracture wound was closed by secondary suture. Part of the wound which could not be sutured was left open to heal spontaneously.

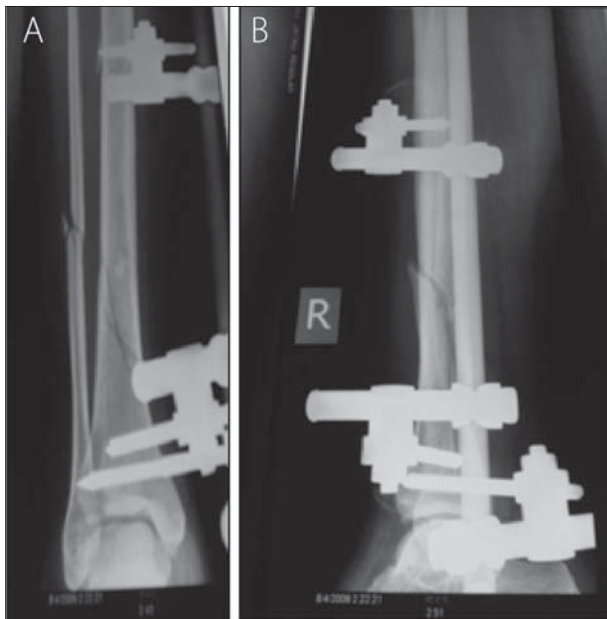


Figure 4. The antero-posterior (A) and lateral (B) X-rays show well-positioned and stabilized fractures of both lower leg bones with external skeletal fixation of tibia



Figure 5. Four months after sustaining an open fracture and undergoing surgical treatment, the antero-posterior (A) and lateral (B) X-rays show the healed fracture of the tibial shaft

External skeletal device was removed after complete fracture healing was achieved. Weight bearing was applied depending of radiological signs of bone healing and physiotherapy was promoted as soon as possible (Figures 5 and 7).

The following postoperative complications were followed up: soft tissue infection of the open fracture wound, pin site infection, chronic osteitis, nonunion, malunion, and limb amputation.

RESULTS

Analysis of the treatment of open lower leg fractures using primary wound management and external fixation has demonstrated that tibial shaft fracture healed without serious complications in 50 (73.53%) patients, whereas in 18 (26.47%) patients we observed the complications which required additional surgical care.



Figure 6. Good early result of the soft tissue defect coverage using free Thiersch's skin graft taken from the thigh of the same leg



Figure 7. The status of the leg after physical therapy; there is a good range of motion in the knee and ankle joints (A); the leg that was operated on is stable, and the patient is fully weight bearing (B).

Average healing time of open lower leg fractures was 22 weeks.

Nonunion (both septic and aseptic pseudoarthrosis) was found in 10 (14.71%) patients, osteitis in four (5.88%), malunion in two (2.94%) patients; amputation was performed in one (1.47%) patient. For the treatment of pseudoarthrosis, the Ilizarov apparatus was applied in four (5.88%) patients, whereas the Mitković compression-distraction device was utilized in six (8.82%) patients.

In two (2.94%) patients, the cause of malunion was pin loosening. In one patient, the correction of angular deformity was done, with good functional result; however, the second patient didn't want to undergo the correction of the deformity.

Three patients with type IIIC open fractures were studied. Lower leg amputation was performed in one patient

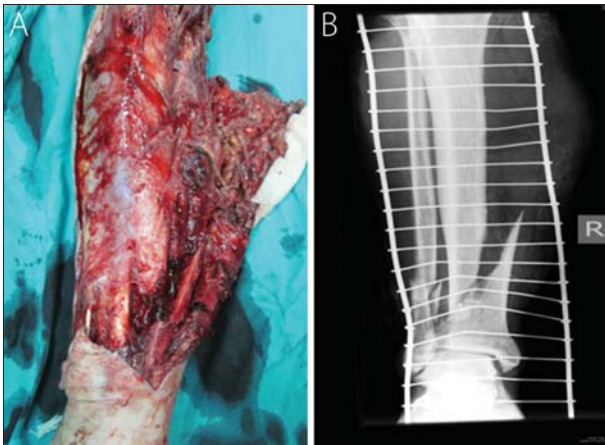


Figure 8. Patient aged 74 years was injured while tilling his garden, when he sustained a severe comminuted fracture of the right lower leg, Gustilo type IIIC (A). The X-ray of the right lower leg shows comminuted fractures of tibia and fibula in the distal lower leg, with displacement of bone fragments (B).

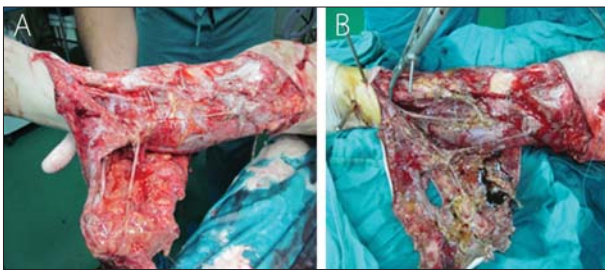


Figure 9. After short preoperative preparation, profuse irrigation of the open fracture wound was done, and all foreign bodies were removed (A). After the reposition of the fracture, external fixator pins were placed first in the distal fragment in the convergent fashion to achieve good stability of the fragment (B).

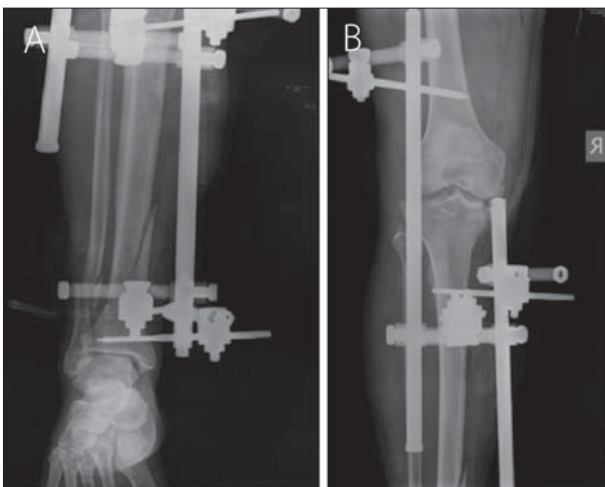


Figure 10. (A) The X-ray demonstrates the distal fracture of the lower leg, after the reposition and fixation using external skeletal fixation; (B) proximal extension of the external fixation device was applied for knee joint bridging to stabilize the tibial medial condyle fracture by ligaments distraction.

who had been run over by a truck and sustained severe type IIIC fracture. Another patient of the group, who had been injured by a roller, sustained concomitant crush injury of the forefoot and amputation was performed. Open tibial fracture of the same lower leg was treated with external fixation. Tear of posterior tibial artery was closed with end-to-end sutures. However, this leg remained shorter



Figure 11. State of the lower leg after primary management of the open fracture wound and external skeletal fixation. Soft tissue defect affects two thirds of the anterior lower leg.

by 2.5 cm. Third patient with the IIIC fracture needed comprehensive treatment including direct suturing of the anterior tibial artery laceration and soft tissue coverage procedures (Figures 8–11).

Milder complications such as soft tissue pin tract infection developed in 13 (19.12%) patients; infection of the open fracture wound was observed in four (5.88%) patients. The treatment of soft tissue pin tract infection included daily dressing of the wound and antibiotic therapy, whereas the management of the infection of the open fracture wound required daily wound dressing, additional surgical wound care and antibiogram-based therapy.

Distribution of the complications in relation to Gustilo classification of open fractures is shown in Table 1. The presence of complications was similar in type I and II fractures. In type III group, nonunion was found in almost one third (27.6%) and pin site infection in 37.9% of patients.

Osteitis developed in three type III fractures (10.3%). In type IIIA, this complication was found in one patient, and in two patients with type IIIB fracture, which is almost one third of the group (28.6%).

Both patients in group IIIC with preserved legs sustained nonunion, which makes 66.5% of the whole group, but in fact it is 100%, because the third patient's leg was primarily amputated (Table 1).

DISCUSSION

The treatment of open lower leg fractures should be considered an emergency, and it includes the following procedures: thorough wound irrigation, wound foreign body removal, primary treatment of the open fracture wound, fracture stabilization, antibiotic therapy, tetanus prophylaxis, and delayed wound closure. Primary treatment of the open fracture wound should be done as soon as possible after injury (certainly within six hours), as rapid development of microorganisms will contaminate the open fracture wound. Primary surgical care of the open fracture wound is one of the most important steps in the fight against infections, both aerobic and anaerobic (gas gangrene and tetanus). It includes the removal of damaged

Table 1. The presence of complications in relation to the type of fracture by Gustilo classification.

Gustilo type	n	Nonunion	Malunion	Osteitis	Wound infection	Pin site infection
I	18	1 (5.5%)	1 (5.5%)	-	-	1 (5.5%)
II	21	1 (4.8%)	-	1 (4.8%)	-	1 (4.8%)
III	29	8 (27.6%)	1 (3.4%)	3 (10.3%)	4 (13.8%)	11 (37.9%)
IIIA	19	2 (10.5%)	1 (5.3%)	1 (5.3%)	2 (10.6%)	5 (26.3%)
IIIB	7	4 (57.1%)	-	2 (28.6%)	2 (28.6%)	4 (57.1%)
IIIC	3	2 (66.7%)*	-	-	-	2 (66.7%)
Total	68	10 (14.71%)	2 (2.94%)	4 (5.88%)	4 (5.88%)	13 (19.12%)

*There was one amputation as a primary treatment of IIIC fracture

skin, subcutaneous fat, fascia, and muscles, as well as removal of small periosteum bone fragments. Debridement of the open fracture wound can be repeated within 24 or 48 hours, and the aim is to remove the necrotic tissue. The debridement is followed by fragment reposition and external skeletal fixation [8].

External skeletal fixation is a standard method for the stabilization of all open lower leg fractures except for type I open fractures, when internal fixation can be applied as well. External skeletal fixation provides good biomechanical conditions for the management of open lower leg fractures, enables good approach and care of the wound, and doesn't disturb the movements of the knee and ankle joints [9].

The problems frequently encountered in external skeletal fixation are soft tissue and bone infections around the external fixator pins, especially when patients wear the device longer than six months [10, 11]. In the series of 171 open fractures treated by external skeletal fixation, Edwards et al. [10] registered 50 (29.24%) soft tissue pin tract infections and four (2.33%) cases of local osteitis developed around the pins. In the series of 101 open tibial fractures treated with external fixation, Marsh et al. [11] observed 39 (38.61%) complications related to pins, 10 of which had to be replaced, and emphasized a low percentage (6%) of deep bone infection at the fracture site.

Naveed et al. [12] reported results of treatment of 60 patients with types II, IIIA and IIIB open fractures, who were treated with primary management of open fracture wound and external fixation. Three to five days after the use of skeletal fixation, the external fixator was removed and final fixation using the Ilizarov apparatus was performed. In patients with type II open fracture and the majority of patients with type IIIA open fracture, delayed wound closure was done. Healing was observed in all the patients. Mean time of fracture healing was 22.24 weeks. The most common complication was pin site infection. Therapy outcome was estimated minimum one year after the exclusion of all mobility aids, applying the Tucker criteria. Forty-eight (80%) patients had excellent results, 10 (16.7%) patients had good results, whereas satisfactory results were observed in two (3.3%) patients. None of the treated patients had poor results [12].

Soni et al. [13] reported their results using Gustilo classification. In a 15-year period, 18 patients with type IIIC open fractures were followed up. There were 15 men and three women in the analyzed group. Mean age was 30.7 years and mean Mangled Extremity Severity Score was 6.9 (3–10). In total, 15 limbs were salvaged, whereas

three were amputated (two primary and one delayed amputation). In four patients, fractures were stabilized using external skeletal fixation; internal fixation was applied in 12 patients. Wound infection was observed in seven, and nonunion in four patients, which required further surgical care. Delayed healing was more commonly observed in the distal tibia fractures when they were associated with the posterior tibial artery lesion. After completion of treatment, 39% of patients could not return to their job [13].

In the reference literature, there are still controversial data related to the treatment of patients with open lower leg fractures associated with the major blood vessel injuries. However, the studies published in the last two decades have shown that salvaged limb provides better quality of life and lower treatment costs in spite of additional surgical care when compared to amputation. A long-term goal of the treatment of the open tibial fracture associated with major blood vessel injuries is to enable patients to return to their daily activities and professional work [14, 15].

In the current traumatology, the primary intramedullary fixation of type I, II, and IIIA open fractures, with proper wound debridement, is gaining popularity [16]. The role of intramedullary fixation in the treatment of type IIIB open fractures is still controversial. Intramedullary fixation in type IIIB open fractures is associated with higher percent of infection and nonunion. Joshi et al. [17] observed infection in 10.7% of cases after the use of intramedullary fixation for the treatment of open fractures, in spite of a thorough debridement and adequate coverage by soft tissues.

An adequate alternative method for the treatment of severe open fractures is a delayed intramedullary fixation after the external skeletal fixation. However, the intramedullary fixation, after the application of the external skeletal fixation of an open tibial fracture, can be associated with increased percentage of infection if the pin site infection was present [18, 19].

Nonunions – both septic and aseptic pseudoarthroses – were observed in 10 (14.71%) patients of the analyzed groups. Papaioannou et al. [20] reported a 10% nonunion rate of type II and III open fractures using the external fixation method. They found that the major problems in the treatment of open lower leg fractures with external fixation, besides nonunion, are pin site infection and malunion.

Golubović et al. [8] published in 2008 results of the delayed wound closure. After surgical care and external skeletal fixation, the open fracture wound wasn't primarily closed, but left open. It was closed when there were

no signs of infection, using a delayed, secondary closure or some of the plastic surgery methods (fasciocutaneous, microvascular flap), which depends on soft tissue defects.

The treatment of type IIIB open tibial fracture is a major challenge and it needs aggressive debridement, adequate fixation, and early flap coverage of soft tissue defect. The flaps could be either nonmicrovascular, which are technically less demanding, or microvascular, which demand steep learning curve and are available in only a few centers. Kamath et al. [21] concluded that open fracture of the tibia which needs flap coverage should be treated with high priority of radical early debridement, rigid fixation, and early flap coverage. The study included 151 cases of Gustilo Anderson type IIIB open tibial fractures which needed flap coverage for soft tissue injury. Ninety-four cases were treated in the acute stage by debridement; fracture fixation and early flap coverage were performed within 10 days. Thirty-eight cases were treated between 10 days to six weeks in the subacute stage. The remaining 19 cases were treated in the chronic stage after six weeks. The soft tissue defect was treated with various nonmicrovascular flaps depending on the location of the defect. A majority of these wounds can be satisfactorily covered with local or regional microvascular flaps.

Franken et al. [22] recommend that all patients with large soft-tissue defects of the lower leg after an open tibial fracture should be initially treated with a local, musculocutaneous flap whenever possible. If the location or size of the defect makes local reconstruction impossible, free flaps remain the only possibility for reconstruction.

Early intravenous antibiotic therapy should be started immediately after sustaining an injury [23]. Right after the admission of a patient with an open lower leg fracture, benzylpenicillin is administered intravenously in the dose of 4,000,000–6,000,000 i.u. per four hours through intravenous infusion, together with an aminoglycoside (amp. amikacin 1 g/24 h). If the wound is contaminated with soil, than, in addition to the aforementioned antibiotics, metronidazole and clindamycin should be included to prevent the occurrence of gas gangrene. This therapy is administered in duration of three days, when benzylpenicillin is

replaced with a third- or fourth-generation cephalosporin. Cefazolin, which covers gram-positive bacteria, should be given for all open fractures. Aminoglycosides, which cover gram-negative bacteria, are obligatory in cases of all open fractures with extensive soft tissue injuries and contamination. As penicillin covers the anaerobes, it is indispensable in cases where there is a risk of wound contamination by these organisms (e.g. *Clostridium perfringens*), which is common in agricultural injuries when wound is contaminated with soil. If benzylpenicillin is not available, a third- or fourth-generation cephalosporin should be administered. In this study, cephalosporins of third generation in combination with aminoglycosides were used as a first step in all patients. The duration of the treatment depended on the type of the fracture and injury circumstances.

CONCLUSION

Treatment of lower leg fractures includes profuse wound irrigation, removal of all foreign bodies, debridement of avital tissues, fracture stabilization using the external skeletal fixation, early reconstruction of soft tissue defects, antibiotic and tetanus prophylaxis, and physical therapy. Open lower leg fractures are associated with a number of complications, the most important of which are pseudoarthrosis (both septic and aseptic) and osteitis. In the analyzed group of open fractures, there were 10 (14.71%) patients with pseudoarthrosis of the tibia and four (5.88%) patients with osteitis. Abiding by the basic principles of the treatment of open lower leg fractures provides limb salvage and good functional result of the injured limb.

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Резултати лечења отворених прелома потколенице спољном скелетном фиксацијом

Иван Голубовић¹, Бранко Ристић², Предраг Стојиљковић¹, Милан Ђирић³, Ивана Голубовић⁴, Зоран Радовановић⁵, Слађана Петровић⁵, Нина Ђорђевић¹, Зоран Голубовић¹, Стево Најман⁶

¹Клинички центар у Нишу, Клиника за ортопедију и трауматологију Ниш, Србија;

²Клинички центар Крагујевац, Клиника за ортопедију и трауматологију Крагујевац, Србија;

³Институт за физиологију, Универзитет у Нишу, Медицински факултет, Ниш, Србија;

⁴Универзитет у Нишу, Медицински факултет, Ниш, Србија;

⁵Клинички центар у Нишу, Институт за радиологију, Ниш, Србија;

⁶Институт за биологију и хуману генетику, Универзитет у Нишу, Медицински факултет, Ниш, Србија

КРАТАК САДРЖАЈ

Увод Отворени преломи потколенице спадају у групу најчешћих отворених прелома локомоторног система и њихово лечење прати читав низ компликација.

Циљ рада Циљ рада је био да се прикажу резултати лечења 68 болесника са отвореним преломом потколенице, као и компликације које прате лечење ових прелома.

Методe рада У анализираној групи било је 45 (66,18%) мушкараца и 23 (33,82%) жене. Највећи број испитаника 33 (48,53%) повређен је у саобраћајној несрећи, док је 24 (35,29%) повређено при паду. Код два (2,94%) испитаника узрок отвореног прелома потколенице било је стрелно рањавање. У анализираној групи било је 18 (26,47%) отворених прелома I степена, 21 (30,88%) II степена, 19 (27,94%) IIIA степена, седам (10,29%) IIIB степена и три (4,41%) IIIC степена.

Резултати Преломи потколенице су срасли без тежих компликација код 50 (73,53%) испитаника, док су код 18 (26,47%)

испитаника регистроване компликације. Несрастање прелома регистровано је код десет (14,71%) испитаника, остеоитис код четири (5,88%), зарастање прелома у лошој позицији код два (2,94%) испитаника. Лакше компликације, мекотивна инфекција око клинова спољног скелетног фиксатора развила се код 13 (19,12%) испитаника, а инфекција меких ткива у пределу ране отвореног прелома код четири (5,88%) испитаника.

Закључак Опсежна примарна хируршка обрада ране отвореног прелома потколенице и њено одложено затварање, стабилизација прелома спољним скелетним фиксатором, антитетанусна заштита и адекватна антибиотска терапија представљају основне принципе у лечењу отворених прелома потколенице у овој студији. Приказани резултати корелирају са сличним студијама.

Кључне речи: отворени преломи потколенице; лечење; спољна скелетна фиксација; постоперативне компликације