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Treatment of tibial shaft fractures with Mitković type external fixation – Analysis of 100 patients

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SUMMARY

Introduction/Objective Tibial shaft fractures (TSF) are one of the most common fractures. External fixation (EF) may be used to treat TSF.
The aim of this study was to analyze the treatment of TSF with Mitković EF.

Methods The study included 100 patients with TSF treated with Mitković EF as the primary and definite method of treatment. The results are compared to those in the literature.

Results The patient group comprised 67% male and 33% female patients aged 10–71years. TSF is common in adult males in the fourth and fifth decades of life. The most common cause is falling with the twisting of the leg (59%). Closed fractures were observed in 76 patients (57.4% of type A AO, 25.4% of type B AO, and 17.1% of type C AO), and open fractures in 34 patients (50% of type I GA, 32.35% of type II GA, and 17.64% of type III GA). The average time period from injury to surgery was 2.5 days (the range being 4 hours to 9 days). Bone healing was achieved in 93% of patients. The average healing time was 18.4 weeks (the range being 11–32 weeks). The distribution of complications is as follows: 10% for minor pin site infections; 4% for major pin site infections; 6% for nonunion; 1% for acute respiratory distress syndrome; 2% for osteitis. There was no deep vein thrombosis nor neurovascular damage. EuroQol score was excellent in 82% of the patients.

Conclusion Mitković EF can be used for treating all types of TSF. Functional results of treatment by this method are excellent. The data analysis of the series does not differ from the data in the literature.

Keywords: tibial fracture, etiology, pathology, surgery; fracture fixation, instrumentation, methods; external fixators; osteosynthesis

INTRODUCTION

Tibial shaft fractures (TSF) are common long bone fractures of great importance. The National Center for Health Statistics (NCHS) reports an annual incidence of 492,000 fractures of the tibia and fibula in the United States [1].

Treatments of these injuries are being debated – whether they are non-surgical or surgical. This can also be said about the method of surgical treatment used [2].

The role of external fixation (EF) in the treatment of these injuries is great and EF is widely used for surgical treatment in accordance with the indication. There are three methods of using EF for the treatment of TSF: 1. EF as the primary and definitive treatment [3]; 2. EF combined with internal fixation [4, 5]; and 3. Conversion of EF to internal fixation [6].

Mitković EF has been used for a long time for surgical treatments of TSF [7, 8]. Biomechanical tests of this type of EF showed remarkable stability of fixation and good biochemical conditions for bones healing [9].

The aim of this study is to describe the method of Mitković EF with the M20 external fixator in surgical treatment of TSF, to examine the effectiveness of this method by analyzing 100 patients treated by this method, and to compare our results with the data in the literature.

METHODS

Patients

This study included 100 patients with TSF who were surgically treated in the 2011–2015 period at the Department of Orthopedic Surgery of the Kosovska Mitrovica Health Center. The surgical treatment was carried out in accordance with the following indications: 1. open TSF; 2. unstable TSF; 3. “damage control” surgery; 4. fractures with “indicators of instability”, such as soft tissues damage, involvement of apophysis or articular surface, the excessive distance of fragments, etc [10]. All the patients were treated using the Mitković EF method with the M20 external fixator. EF we used as the primary and definitive treatment method.

In this study, we analyzed the age, gender structure, and the causes of injury. For the clas-

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sification of fractures, we used the AO classification of closed fractures and Gustilo–Anderson (GA) classification of open fractures. At the end of the treatment, we analyzed the outcome, the way we treated the patients, and the treatment complications. The patients' quality of life after the treatment was examined with EuroQol-5d scoring system.

The surgical technique and treatment methods

M20 is a unilateral fixator using pins that we placed in the tibia in the "safe zones" [11]. It is very important to set the correct position of M20 with convergent pins, placed at an angle of at least 60 degrees. The fixator body must be placed between fixator pins in the axis of the tibial diaphysis. Only in this way M20 shows its exceptional biomechanical properties [9]. The proper position of the M20 fixator is shown in Figure 1.

We placed pins before the closed or open reduction of bone fragments, after which we placed the rest of the fixator construction. We used four pins, but depending on the weight of the patient, the type of the fracture, the degree of comminution, and the estimated length of the carrying fixator, we can place more than four pins. Minimal osteosynthesis can be done in the zone of fractures in open reduction. In a few cases, when TSF included the involvement of the distal tibia, we made a combined construction: dynamic EF of the ankle joint and standard EF for TSF, for additional stabilization, as shown in Figure 2 [12].

In similar fractures (TSF with the fracture of the proximal tibia) we performed an EF combined with internal fixation, shown in Figure 3.

In cases of closed TSF, we always use closed reduction of bone fragments and EF after obtaining adequate position of bone fragments. In several cases with an inadequate position of the bone fragments after closed reduction, we did open reduction with a minimally invasive approach. After two weeks, we allowed the partial reliance on the injured leg. Pin site is carried out after three to four days.

In cases of open TSF, we used the following protocol [8]: early surgery (within six hours of injury if possible), profuse irrigation of the wound, extraction of any foreign bodies, hemostasis, debridement of soft tissues, EF (neurovascular procedure if necessary), and drainage. We used the following combination of antibiotics: cephalosporins of the third and fourth generation and aminoglycosides. In the cases of heavily infected wounds we used metronidazole as the third antibiotic. Anti-tetanus prophylaxis was given to all patients with open fractures according to the protocol. After that, each patient was again carefully examined and further course of treatment or the need for new surgery was determined.

Figure 1. Proper position of the Mitkovic M20 external fixator (for **Figures 2–14** please click on the figure)

We used EF in children after the careful assessment of their age, weight, type of fracture and the need for surgical treatment [13]. We placed fixator pins outside the zone of the epiphysis, while the rest of the treatment is similar to treatment done to adults.

We used nadroparin for thromboprophylaxis according to the protocol in all the patients except children.

RESULTS

Our study included 67 (67%) male and 33 (33%) female patients. The classification of our patients according to age is given in Table 1. Our youngest patient was 10 years old and the oldest one 71 years old. Based on this, we can say that our study shows that adult men in their thirties and forties are the age group injured most frequently.

We treated four children with TSF, aged 10, 12, and 13 years. For two children, it was open fractures type I GA, one child had an AO type B fracture, and one child was with a bilateral TSF (shown in Figure 4).

The most common cause of injury was indirect force (falling on the leg with twisting of the foot or the whole lower part of the leg), with 59% of the cases, followed by the action of a direct force, such as traffic traumatism, with 22%, hitting the lower leg, with 17%, and gunshot injuries, with 2% of the cases.

TSF was closed in 76 patients (type A AO with 57.4%, B AO with 25.4%, and C AO with 17.1%). The patients were surgically treated on average within 2.5 days of the hospitalization, and after four hours in the earliest cases (in patients with threatening compartment syndrome and polytraumatized patients in "damage control" surgery) and no later than 9 days (the patient with heart problem). In 64 (84.21%) patients we achieved a satisfactory position of bone fragments using closed fracture reduction, even in fractures with great bone comminution, shown in Figure 5. In other cases we performed an open reduction of fractures and EF, using a minimally invasive approach. In four cases we used minimal internal osteosynthesis (screw,

Table 1. Classification of patients by age

Patient age	n (%)
2nd decade	10 (10%)
3rd decade	16 (16%)
4th decade	26 (26%)
5th decade	23 (23%)
6th decade	13 (13%)
> 60 years	12 (12%)

wire, or hemicortical pin). Hemicortical pin for additional stabilization is shown in Figure 6.

Our study included 34 patients with open TSF. The majority of patients was with small damage of skin and soft tissue: I GA in 17 cases (50%) and II GA in 11 cases (32.35%). Six (17,64%) patients were with severe soft tissue damage of III GA (1 IIIa GA, 3 IIIb, and 2 IIIc). All the patients with open TSF were surgically treated within six hours of hospitalization. We used the above listed combination of antibiotics. The antibiotics were given immediately after admission to hospital and before the surgery. We continued to administer the antibiotics in type I GA patients up to 72 hours after the operation. To type II GA and III GA patients, the antibiotics were given at least 7 or 14 days, depending on when the sterile microbiological findings were obtained.

All the patients with III GA open fractures had a daily wound care and periodic debridements if necessary. In two patients, the Thiersch transplant skin graft was made.

In one patient, multiple injuries of a. tibialis posterior were found. After a careful wound care, repeated debridements, subsequent secondary sutures, and Thiersch skin transplant, we achieved a satisfactory result. The patient is shown in Figures 7 and 8.

In another case, a patient with an open IIIc GA TSF on the right leg and a II GA open fracture of the left ankle joint was hospitalized with signs of severe traumatic shock due to severe bleeding and signs of serious violations of the blood vessels in the upper part of the lower leg, shown on Figures 9 and 10. He was injured in a car accident and spent nearly two hours stuck under the truck. After initial reanimation we did a surgical procedure of "damage control," an urgent bilateral EF. Reanimation of the patient lasted several hours and included five units of blood transfusion in addition to other procedures. Due to the severity of injuries of blood vessels in the upper part of the right lower leg the patient was referred to the relevant tertiary institution after receiving the overall status that allowed the transport of the patient. Despite the surgical procedures on blood vessels, the amputation of the right leg above the knee was performed in the end.

We had two patients with gunshot injuries of the lower legs. In both cases we achieved excellent results. One of them is shown in Figures 11 and 12. In this patient, we combined a classical surgical treatment with hyperbaric oxygen therapy, which proved to be a good combination for a faster healing of wounds.

The average time for fracture union was 18.4 weeks (the range being 11–32 weeks). We achieved the bone union in 93% of the patients. The decision to remove the fixator was made on the basis of clinical and radiographic findings and the length of treatment. In patients that seemed to have adequate healing we conducted a simple test shown in Figure 13. We removed the fixator and kept pins in the bone, allowed full reliance on the injured leg and followed the clinical and radiographic findings after a few days. If the clinical and radiographic findings were normal, we removed the pins. We continued with the EF treatment in patients who felt pain in the region of the fracture or where there were changes in radiographic findings. After the removal of EF we applied plaster to four patients in order to protect the resulting union. These were our oldest patients.

Table 2. Soft tissue complications in closed tibial shaft fractures

Complication	n (%)
Epidermolysis bullosa	8 (8%)
Dermoabrasion	4 (4%)
Skin necrosis	2 (2%)
Threatening compartment syndrome	2 (2%)

Table 3. The presence of complications during treatment

Complication	n (%)
Minor pin infection	10 (10%)
Major pin infection	4 (4%)
Nonunion	6 (6%)
ARDS	1 (1%)
Osteitis	2 (2%)
Amputation	1 (1%)

ARDS – acute respiratory distress syndrome

Table 2 shows the complications of soft tissue in closed fractures. The most common complication was epidermolysis bullosa. We removed blisters and dried the spots with an antibiotic spray. Minor injuries to the skin (dermabrasions and less frequently postcontusion skin necrosis) were treated carefully. In two patients that were threatened with the compartment syndrome we made an emergency fasciotomy of the lower leg.

The most common complication in our study was related to the pin-tract infection (PTI) in 14 (14%) patients. Although the literature cites multiple classification systems related to the problem of PTI, we used a simple classification on minor and major infections, described by Ward in 1984 [14]. In all the patients with problems related to pin site (pain, swelling, secretion, erythema, itching, etc.) we did a microbiological analysis of the pin insertion using a swab, then we manually tested the pin stability and did an X-ray examination. The patients with minor infections were treated with daily pin site care and antibiotic therapy (positive microbiological analysis) and a careful assessment of the pin stability. The patients with major infections were treated in hospital. In patients with positive microbiological analysis, the signs of pins instability, and radiographic signs of bone osteolysis around the pins, we removed the pins and placed them in a different location.

Nonunion was found in six (6%) patients (two with closed TSF, four with open TSF), shown in Table 3. For the treatment of nonunion, the Ilizarov EF was applied in two (2%) patients, whereas the Mitković EF with compression–distraction device was used in four (4%) patients, shown in Figure 14. In all the patients we achieved bone healing.

The EQ-5D (EuroQol) questionnaire was used to assess these patients at the end of treatment. Excellent results were achieved in 82% of the patients.

In our study we did not have patients with DVT and injuries of neurovascular bundles while placing pins. Also, we did not have any mechanical damage to the M20 construction, in terms of bending or fracture of the structure.

DISCUSSION

The TSF are common injuries that remain challenging to treat because of the wide spectrum of fracture patterns and soft tissue injuries. Understanding the indications for surgical and nonsurgical treatment of these fractures is essential for good outcome [15].

The debate on TSF treatment is ongoing. Operative treatment can be performed with several different implants. Intramedullary nailing (IMN) with a huge biomechanical stability seems to be the implant of choice. The use of EF is still the implant of choice in the first line treatment of multiple traumas according to the damage control principles [16].

EF of TSF with the M20 fixator is a simple and effective method to enable the safe healing of fractures, early mobilization of patients, early weight-bearing, as well as early rehabilitation [17].

The previous three citations describe the dilemma we had during our research. Can EF be used as a universal method of treatment in patients with TSF, and how to properly select patients for surgical treatment? Currently, the data on using IMN as the method of choice in treating TSF are dominant. The role of EF is mainly reduced to a temporarily osteosynthesis, in polytraumatized patients in the procedure of "damage control" and the treatment of open TSF. The use of IMN is described in the literature even for the most serious III GA open fractures. [18].

In our institution, the Mitković EF has been in use since 1998 and 375 patients with TSF have been surgically treated so far. In the beginning, we treated patients with high bone comminution and open TSF. Functional results of treatment of such fractures were excellent and we expanded the list of indications for surgery in patients with unstable closed fractures as well as patients who had "indicators of fracture instability." EF is particularly suitable for the treatment of segmental TSF and other high bone comminution (gunshot injuries, traffic traumatism, etc.). According to McMahon et al. [19], IMN has the fastest time to fracture union in segmental TSF; however, there are concerns regarding an increased deep infection rate in open segmental TSF. In this subgroup, the data suggest that the EF provides the most satisfactory results. In our 15-year use of the M20 fixator for TSF, we never had a mechanical damage to the M20 structure. In patients who had no problems with the PTI, a remarkable biomechanical stability of the Mitković EF enabled long-term use of fixators, but good stability is guaranteed only with an adequately positioned fixator and a proper pin site care. Only in this way does the Mitković EF show its exceptional biomechanical properties [9].

Gender structure (67% of male and 33% of female patients) and injuries most common in the fourth and fifth decades of life correspond to the data in the literature [1]. The most common cause of injury was the effects of indirect forces, which was the case in 59% of the patients, followed by the effect of a direct force, with 41% of the patients. The distribution of fractures classified in the AO system followed the cause of injury (54% for AO type A, 27% for type B, and 19% for type C), and corresponded to the intensity distribution of forces.

EF was used in four children on the basis of a careful assessment of the child's age, weight, and the type of fracture. Children adapted very quickly to the method of treatment and functional results of the treatment were excellent. According to Kinney et al. [20], the initial treatment outcomes between the operative fixation and closed reduction of the displaced tibia fractures in adolescents are similar, but patients must be counseled about the high failure rates with closed reduction. In a study covering 106 adolescents, Marengo et al. [21] reported that the average patient age at the time of injury is 13.5 ± 1.3 years (the range being 11.3–16.1). The mean patient weight was 57 ± 8 kg. This study demonstrates that the use of elastic stable intramedullary nailing for displaced TSF in children and adolescents weighing 50 kg (110 lb) or more, or older than 13 years, is not contraindicated.

Average healing time of 18.4 weeks and achieving bone union in 93% of the cases is in accordance with the data in the literature.

Distribution of complications (shown in Table 3) is similar to the data in the literature. Beltsios et al. [3] published similar information. In our study, the most common complication was PTI (14%). Ramos et al. [22] reported a similar pin site problems. Proper identification of PTI and a quick response is of the utmost importance, as pin instability is the instability of the entire EF [14].

Tibial nonunion is estimated to constitute 2–10% of all tibial fractures. The incidence is greater with high-energy injuries and open fractures [23]. In our series, we had 6% of nonunions, which does not deviate from the data in the literature. In all the patients we achieved bone healing and good functional results.

There was a significant positive correlation in patients with TSF between functional outcomes and the EQ-5D score [24]. In our study, an excellent result was achieved in 82% of the patients (EuroQol 5D), but the level decreased with the severity of injuries (fasciotomy, grade IIIB / IIIC open fracture, and amputation). Giannoudis et al. [25] state that patients with these injuries still report long-term problems with their health-related quality of life, though to varying degrees.

CONCLUSION

Properly placed Mitković EF can be used to treat even the most serious TSF fractures as it provides optimum biomechanical conditions for bone healing and excellent stability of osteosynthesis. Closed reposition of TSF and EF is a method of treatment and provides exceptional results. EF has a precious role because it is used in treatment of open TSF. A combination of early surgery, profuse wound irrigation, removal of all foreign bodies, debridement of avital tissues, fracture stabilization using the external EF, early reconstruction of soft tissue defects, antibiotic and tetanus prophylaxis, is a method of choice in open TSF treatment, even in type III GA, the most complex open TSF. This method of TSF treatment gives excellent functional results, and allows for the possibility of early rehabilitation in a very short period of time after surgery, particularly in patients with closed TSF and which are performed by closed reduction of fragments. The patients were generally tolerant to long-term treatments using EF. In our study, the quality of life of patients described by EuroQol 5D scoring system proved to be excellent in 82% of the cases. We believe that early surgical treatment is of extreme importance in patients with TSF. The average healing time of 18.4 weeks and bone union in 93% of the cases is in accordance with the data in the literature. In this study, we showed the number, type, and method of treatment of complications, and our data do not deviate from the data in the literature. In a larger percentage of patients (14%), pin site problems can be considered regular attendant problems related to EF in the region of the lower leg during prolonged wearing of EF. Proper identification of pin site problems, adequate response, and treatment are of utmost importance.

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Лечење прелома потколенице спољашњом фиксацијом по Митковићу – анализа 100 болесника

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САЖЕТАК
Увод/Циљ Преломи потколенице (ПП) једни су од најчешћих прелома и могу се лечити спољашном фиксацијом (СФ). Циљ овог рада је био да анализира резултате лечења ПП помоћу СФ по Митковићу.
Метод Студијом је обухваћено 100 болесника са ПП лечених СФ по Митковићу као примарним и дефинитивним методом лечења. Резултати су упоређени са литературним подацима.
Резултати Група болесника састојала се од 67% мушкараца и 33% жена, старости 10–71 године. ПП најчешће задобијају одрасли мушкарци у четвртој и петој декади живота. Најчешћи узрок је пад са извртањем ноге (59%). Затворених прелома је било код 76 болесника (тип А АО 57,4%, тип Б АО 25,4% и тип Ц АО 17,1%). Отворених прелома је било код 34 болесника (тип I ГА 50%, тип II ГА 32,35% и тип III ГА 17,64%). Просечно време до оперативног захвата било је 2,5 дана (4 ч – 9 дана). Зарастање је постигнуто код 93% пацијената, а просечно време зарастања је било 18,4 (11–32) недеље. Компликације лечења су биле: минор инфекција клина 10%, мајор инфекција клина 4%, незарастање 6%, АРДС 1%, оститис 2%. Дубоких венских тромбоза и неуроваскуларних оштећења није било. Анализа квалитета живота помоћу *EuroQol* скора била је одлична код 82% болесника.
Закључак СФ по Митковићу се може употребити за лечење свих типова ПП. Функционални резултати лечења овом методом су одлични. Подаци добијени анализом серије не одступају од података у литератури.

Кључне речи: преломи потколенице, етиологија, хирургија; фиксирање прелома, инструменти, методе; спољни фиксатори; остеосинтеза