

## **OPERATIVE TREATMENT OF III GRADE OPEN FRACTURES OF THE TIBIAL DIAPHYSIS**

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**Abstract:** Open fractures, especially III grade open fractures of the tibial diaphysis, according to the Gustilo classification still remains a serious therapeutic problem. The aim of the study was to evaluate the clinical results after operative treatment of III grade open fractures of diaphysis of the tibia and to promote a new method of fracture fixation.

**Material and methods:** 48 patients with open fractures of the tibial diaphysis, classified as type III A and B, according to the Gustilo classification, were operatively treated. Patients were divided into two groups depending on the manner of fracture fixation. Patients in group A (30 pts.) were treated with an external fixator and those in group B (18 pts.) with unreamed intramedullary nails. The time of the union of the fracture, problems with the union (malunion and nonunion), infection, different complications and the functional outcome were examined. Late complications and their treatment were not the object of the study. The follow-up period was at least 12 months.

The results of the study showed a mean time of union of 38.4 weeks in patients in group A, and 32.8 for those in group B. Malunion was noticed in 5 (16.6%) in group A and 2 (11.1%) in group B, nonunion in 4 (13.35) in group A and in 2 (11.1%) patients in group B. Superficial infection developed in 7 (23.3%) and deep in 6 (20 %) of the patients in group A and in group B in 4 (22.2%) and 2 (11.1%) of the patients. Results from the functional examination showed 26.6% excellent and the same percent of fair results in group A. In group B there were 55.5% excellent and 11.1% fair results. Different types of complications were noticed in the patients from both groups. The final results of the examination showed a shorter time of union, a lower percentage of complications and a better functional outcome in the patients in group B.

Unreamed intramedullary interlocking nailing of open fractures of the diaphysis of the tibia (grade III A and B according Gustilo classification) is a relatively safe method of operative treatment with fewer complications compared with external fixation.

**Key words:** open fractures, tibial diaphysis, intramedullary nailing, external fixation

### *Introduction*

Management of open tibial fractures continues to be a major therapeutic problem and a challenge to surgeons [1]. Open fractures in most cases are a result of a high-energy trauma. The normal anatomy of the tibia in conjunction with the complexity of the open fracture (the fractures themselves and soft tissue injury are the factors which influence the manner of fracture treatment, time of union and complications) makes this type of fracture difficult to treat [2, 3].

The aim of the operative treatment is to achieve an anatomically functional extremity which allows early recovery of the patients and a return to the activities which were carried out before the injury [4].

Surgical treatment of open fractures means treatment of the soft tissue injuries and the stabilization and fixation of the fracture [2, 5, 6].

Before the introduction of intramedullary nailing the most common and accepted operative treatment of open tibial fractures was external fixation. This surgical technique gained widespread acceptance because of the advantage of its relatively fast and easy application [7, 8].

In the last few years, however, few authors have pointed out the disadvantages of this method, such as: inadequate fracture stabilization which very often produces malunion and nonunion of the fracture, the difficult soft tissue treatment of the wound, pin site infection, discomfort of the patient and in most cases bad functional results [2, 4, 7, 8, 9].

Those are the most relevant factors which have influenced surgeons to change the method of fixation for open tibial fractures. Nowadays, intramedullary fixation, especially with unreamed intramedullary nails, has taken its place in the surgical treatment of open tibial fractures, even in grade III according to the Gustilo classification [2, 10, 11].

Locking nailing without reaming causes less damage to the intramedullary blood supply and is considered to be a safer method of treatment for open tibial fractures [10]. Small calibre nails were inserted without reaming in order to avoid thermal injury and to minimize disruption to the remaining tibial blood supply. Unreamed interlocking intramedullary nails offer the advantages of stable fracture fixation, a shorter time of union with less percent complications and a good functional outcome [1, 6, 7, 9, 10].

The aim of this study is to evaluate the clinical results after operative treatment of III grade open tibial fractures according to the Gustilo classification.

### *Material and methods*

From 1999–2004, 48 patients with III A and B grade open tibial fractures according to the Gustilo classification were operatively treated at the Traumatology Clinic of the Clinical Centre in Skopje. Patients with type III C open tibial fractures were excluded from the study. All the patients were divided into two groups depending on the manner of operative treatment. In group A all the patients were operatively treated with external fixation and in group B with unreamed interlocking intramedullary nails. The fractures were classified according to the modified Gustilo classification of 1984 which is widely accepted in surgical practice. Early definition of the type of fracture and the degree of soft tissue damage makes a contribution to proper surgical treatment, the final outcome and a comparison of the results [11].

Thirty patients were treated in gr. A and 18 in gr. B. The mean age of the patients was 37.7 years; 30 of them were male and 18 female. The most common cause of injury was traffic accidents, in 28 cases. In the others the cause of injury was a fall. Isolated trauma were noticed in 26 patients. The others were polytrauma and multitrauma patients. The patients were treated in the first 12 hours after admission to the hospital. All the patients were administered antitetanic and antibiotic prophylaxis, a combination of cephalosporin and klindamicin.

The first step after admission to the emergency ward was clinical evaluation of the injury, sterile dressing, temporary immobilization and the necessary laboratory and radiology investigations. Standard roentgenograms (AP and profile) of the injured extremity were done. Further surgical treatment was performed in the operating theatre. All the patients underwent the same surgical protocol divided into two parts:

1. surgical debridement of the soft tissue injury, including all devitalized soft tissue and bone fragments with lavage of the wound with a low pressure NaCl solution;
2. stabilization, fixation of the fracture.

For that purpose the patients in gr. A were treated according standard operative technique with an external fixator, Hoffman or AO type, with different frames.

Unreamed interlocking nails were used for the fracture stabilization of the patients in gr.B. The standard nailing procedure was performed on an extended operating table, under roentgenscopy.

Postoperatively, most of the patients' wounds were left open or partly open, and they were treated with routine dressing after the operation. In the cases when it was necessary, repeated debridements were performed. In most cases, soft tissue coverage was done with a Thirsh skin transplantat.

Antibiotic therapy was administered to the patients in both groups (a combination of cephalosporin and klindamicin). When the specific bacteria were isolated, the antibiotic therapy was given according to the relevant antibiogram.

No kind of immobilization was necessary for any of the patients.

The follow-up period was at least 12 months.

The study was retrospective-prospective.

The time of the union and problems with the union, infection, different types of complications during the treatment and after that and final outcome were the parameters which were examined. Late complications and their treatment, such as osteomyelitis, were not the object of the study.

Union was defined as a bridging callus crossing three of four cortices of both plain radiographs with no pain on palpation over the fracture site or when bearing weight.

Nonunion was defined as an absence of a bridging callus across a fracture site after an expected time interval for that injury (12 months in our study). As such, deciding that a fracture was a delayed union or a nonunion depended on the extent of the injury incurred in each individual case. These were high-energy injuries with significant periosteal stripping and soft tissue compromise.

Infection was determined by clinical findings of local erythema, swelling, tenderness, or a pus discharge and a positive bacterial culture.

Malunion was defined as a varus or valgus angulation of more than 5 degrees or anterior or posterior angulation of more than 10 degrees.

The functional evaluation was based on pain, range of motion, and ability to return to normal work. Excellent results required at least 5 points, good 4 and fair results at least 2 points [8].

Statistical analysis of the results was performed with the Statcalc commercial statistical programme.

### *Results*

The results of the study showed a mean time of union in the patients of group A of 38.4 weeks, malunion in 5 (16.6%), with angulation of more than 15 degrees and nonunion in 4 (13.3%) patients.

Superficial wound infection was noted in 7 patients (23.3%) and deep infection in 6 patients (20%). The most common bacteria isolated were Gram positive cocci and gram negative bacilli. Postoperative wound fistulas developed in 6 patients (20%) in group A. Two of them were treated conservatively with antibiotic therapy according to the antibiogram. Operative treatment was needed for 4 patients.

A specific problem was discomfort of the patients during the time of the fixation with the external fixator. This subjective feeling was also noted in a few patients in the period after the removal of the external fixator.

After the removal of the external fixator all the patients needed a long rehabilitation period. A high percentage of fair functional outcomes was noted in the patients in group A. Only 6 (20%) of them were able to return to their normal activities. The results of the functional evaluation showed 8 excellent (26.6%), 14 good (46.6%) and 8 fair results (26.6%).

In 16 patients (53.3%) in group A additional surgical procedures were performed. Some of them needed more than one. Sixteen patients needed a Thirsh skin transplantat to cover the skin defects. Correction of the frame or pins of the fixator were performed for 12 patients (40%). A bone grafting procedure was carried out on 10 patients (30%). Conversion of the external fixator to an intramedullary nail was done for 6 patients (20%).

The mean time of hospitalization for the patients in group A was 21.6 days. Most of the patients in group A needed repeated hospital stays.

The results of the evaluation of the patients in group B showed a mean time of union of 32.8 weeks, with malunion in 2 (11.1%) and nonunion in 2 (11.1%) patients. In these two patients with maleunion, unreamed nails were replaced with calibrated nails of a larger diameter. Nonunion developed in two polytraumatised patients.

Superficial infection was noted in 4 (22.2%) patients and deep infection developed in 2 (11.1%) patients. One of them was treated conservatively and for the other, removal of the nail and refixation with an external fixator was necessary.

Deep venous thrombosis developed in one patient (5.5 %).

Additional surgical procedures for covering the wound were performed in 6 patients (33.3%). Five of them needed a Thirsh skin transplantat and one a muscle-skin transplantat.

Bone grafting was carried out for 2 patients (11.1%).

Metal failure with broken interlocking screws was noted in 4 patients (2.2%).

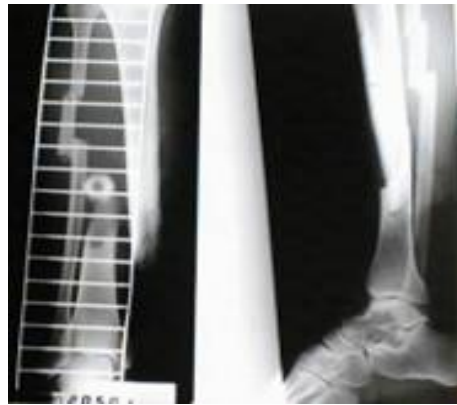
The functional outcome showed 10 excellent (55.5%), 6 good (33.3%) and 2 fair (11.1%) results. Prolonged anterior knee pain was noted in 4 patients (22.2%).

The mean time of hospitalization was 17.6 days.

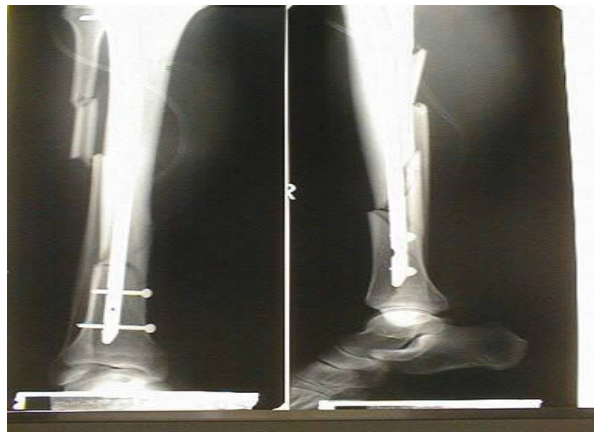
The results of statistical analysis of the comparable parameters of both groups showed statistically significant differences in a few of them. A shorter time of union ( $p < 0.001$ ) and better functional results ( $p < 0,04$ ) in the examined group B patients operatively treated with intramedullary nails. In other parameters examined, such as nonunion, malunion, superficial and deep infection there were no statistically significant differences between the groups examined.



*Figure 1 – III grade open fracture of tibial diaphysis*  
Слика 1 – Оtvорена скршеница на дијафизата на тибиијата од III степеи



*Figure 2 – Rentgenograms of III grade open tibial fracture*  
Слика 2 – Рендгенграфи на отворена скршеница на тибиијата од III степеи



*Figure 3 – Unreamed intramedullary fixation of III grade open tibial fracture*  
Слика 3 – Некалибрирана интраведуларна фиксација на отворена скршеница на тибиијата од III степеи



*Figure 4, 5 – External fixation of III grade open tibial fracture*  
*Слика 4, 5 – Надворешна фиксација на отворена скршеница*  
*на тибиа од III степен*

### *Discussion*

Open fractures of the tibia usually indicate a high-energy injury to soft tissue and bone with resultant problems of infection and poor bone healing [7].

The universally accepted principles of management of open fractures of the tibia include immediate wound debridement and irrigation, skeletal stabilization, repeated wound debridement, and early soft tissue coverage. The methods of bone stabilization, however, have evolved over the years but remain controversial [1, 5].

Before the introduction of the locked intramedullary nail, these injuries were managed where possible with external fixation. This technique gained widespread acceptance because of its ease and speed of application [1, 2, 7].

Concerns regarding the introduction of metal into an area of potential bacterial contamination meant that interest in external fixation developed quickly, and soon it was the accepted method of managing these injuries. External fixation is an excellent initial method of skeletal stabilization in injured, often unstable patients [1, 8, 12].

The obvious disadvantage of external fixation is that it is frequently a bulky device, making soft tissue procedures more cumbersome, and carries a high incidence of pin-site infection. Intramedullary fixation, on the other hand, allows easy access to overlying soft tissue injuries but theoretically disrupts the precarious remaining endosteal blood supply to the fracture fragments [7, 13].

In the treatment of type III open tibial fractures the unreamed nail has been reported to be better than the reamed nail in lowering the infection rate, probably because of less disruption of the endosteal blood supply [13, 14]. Nailing without reaming, with small diameter nails, however, does not provide adequate stability for comminuted, proximal third or distal third fractures of the tibia. The development of interlocking nails has solved this problem by the insertion of bolts through both ends of the nail to provide the stability needed for fracture healing. The advent of a small diameter interlocking intramedullary (IM) nail has introduced a new treatment option that has both the benefits of the unreamed nail and adequate stability [5, 12].

Nail insertion without reaming, however, has provided clear improvements in blood supply to the bone which has contributed to better unions and lower rates of infection [7, 10, 12, 15].

The advantages of unreamed interlocking nails include the avoidance of malunion, malrotation, or leg length discrepancy, the preservation of endosteal circulation, better cosmetic results, and easy access for soft tissue procedures. The disadvantages include hardware failure, a more complicated technique, radiation exposure and higher infection rates in mangled lower extremities [7, 8, 14].

The current trend of using unreamed interlocking nails for open type III tibial fracture stabilization appears to be sound [14].

Based on the clinical results of our study, the immediate unreamed interlocking nail for the fixation of open type III A and III B tibial fractures offers the lowest complication rate and can be recommended above the external fixator.

A sterile metal does not cause infection, but sterile metal in the face of inadequate debridement or absent soft tissue coverage does lead to infection in devitalized soft tissue and bone. The judicious choice of internal or external fixation for open type III tibial fractures allows adequate bone stabilization of virtually all fractures and, with adequate debridement as well as early soft tissue coverage, leads to favourable results [2, 3, 14].

### *Conclusion*

The important factor in fracture healing and in the body's ability to resist infection is the viability of the surrounding soft tissue. Operative care of the soft tissue wound is critical in the treatment of open fractures. Adequate debridement of the soft tissue and bone fragments with stable fixation of the fracture is the key to minimizing deep infection after these injuries.

For the fracture fixation, we recommend the unreamed interlocking intramedullary nail over external fixation in the treatment of grade III A and B



injuries of the tibial diaphysis. It is a safe, effective technique with a comparatively low complication rate. Management of concomitant soft tissue injuries is consistently easier, and patients can make an earlier recovery with a better functional outcome.

This is a preliminary study which included a relatively small number of patients operated on over a short period of time and it had the aim to promote a new operative method. The application of this method to a larger series of patients and a longer evaluation of the results with statistical analysis of more parameters, will probably solve the existing dilemma regarding adequate operative treatment of open fractures of the tibial diaphysis.

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### Резиме

## ОПЕРАТИВЕН ТРЕТМАН НА ОТВОРЕНИТЕ СКРШЕНИЦИ НА ДИЈАФИЗАТА НА ТИБИЈАТА ОД III СТЕПЕН

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Отворените скршеници на дијафизата на тибията од III степен според класификацијата на Gustilo се уште претставуваат сериозен терапевтски проблем.

Оперативно беа третирани 48 пациенти со отворени скршеници на дијафизата на тибията од III А и В степен. Пациентите беа поделени во две групи според начинот на фиксација на скршениците. Во групата А беа пациенти оперативно третирани со надворешен фиксатор (30 пт.), а во групата Б со некалибриран заштрафен интрамедуларен клин (18 пт.).

Целта на студијата беше да се евалуираат клиничките резултати од оперативниот третман на отворените скршеници на дијафизата на тибията и да се споредат добиените резултати, но истовремено и да се промовира нов метод на фиксација.

Беа испитувани времето на зараснување и проблемите при зараснувањето, како што се: лошо зараснување односно незараснување на скршениците, појава на инфекција и други компликации, како и крајните функционални резултати. Подоцнежните компликации и нивниот третман не беа предмет на оваа студија. Период на следење беше најмалку 12 месеци.

Резултатите од испитувањето покажаа средно време на зараснување од 38,4 недели кај пациентите од групата А, а 32,8 кај групата Б. Лошо зараснување беше забележано кај 5 (16,6 %) а незараснување кај 4 (13,3%) пациенти од групата А. Во групата Б лошо зараснување се јави кај 2 (11,1%) пациенти, а незараснување исто така кај 2 (11,1%). Површна инфекција се појави кај 7 (23,3%) пациенти од групата А, а длабока кај 6 (20%). Во групата Б површна инфекција беше забележана кај 4 (22,2%), а длабока кај 2 (11,1%) пациенти. Функционалните резултати од испитувањето покажаа 26,6% одлични, но исто толку и лоши резултати во групата А, додека во групата Б имаше 55,5% одлични и 11,1% лоши резултати. Третманот на овој тип на скршеници е оптоварен со висок процент на различни компликации во двете испитувани групи.

Крајните резултати од испитувањата покажаа побрзо време на зараснување, следено со помал процент на компликации, како и подобри функционални резултати во групата Б.

Некалибрираната зашрафена интрамедуларна фиксација на отворените скршеници на дијафизата на тибигјата од III А и В степен според класификацијата Gustilo е релативно сигурна метода, која дава помал процент на компликации од оперативниот третман со надворешен фиксатор.

**Клучни зборови:** отворени скршеници, дијафиза на тибигја, интрамедуларна фиксација, надворешен фиксатор

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