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ANALYSIS OF SURGICAL TREATMENT RESULTS IN PATIENTS WITH FRACTURES OF THE TIBIAL BONES

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ABSTRACT

Relevance: By frequency, tibial bone fractures rank second, accounting for 13% to 21.4% of all musculoskeletal injuries or 64.3%-70% of lower limb bone fractures. The nature of the injury is the result of high-energy trauma and is accompanied by severe soft tissue damage and a comminuted type of fracture. Temporary disability of patients with tibial fractures varies from 8-10 weeks to 5-7 months, and for complex fractures, it can reach 10-12 months. The purpose of the study was to conduct a comparative analysis of the treatment results of patients with tibial bone fractures and to evaluate the effectiveness of different methods of osteosynthesis. **Material and methods:** Depending on the method of operative treatment, the patients were divided into two groups. The experimental group included 113 patients, mostly with diaphyseal fractures of the tibial bones, who underwent surgery with the use of blocking intramedullary osteosynthesis. The control group consisted of 166 patients with tibial bone fractures who underwent intracortical or trans-cortical osteosynthesis. **Results:** The use of low-traumatic methods of stable fixation for the patients of the main group, the possibility of early functional rehabilitation, measures to prevent joint contractures since the first days, the possibility of early dosed loading on the operated limb ultimately led to faster healing of tibial fracture and a shorter overall treatment time. In the main group of patients, fusion was observed from 8 to 22 (11.56 ± 2.56) weeks, in the control group - from 12 to 36 (18.68 ± 4.70) weeks. The general treatment period for patients in the main group ranged from 8 to 22 (14.44 ± 2.85) weeks, while for the control group, it was from 13 to 43 (21.23 ± 5.38) weeks. **Conclusion:** The use of blocking intramedullary osteosynthesis has demonstrated its high effectiveness in the surgical treatment of patients with metadiaphyseal fractures of the tibia, allowing for positive treatment results in 96.66% of patients. The advantage of blocking intramedullary osteosynthesis is the biomechanically justified high stability of fixation and minimal invasiveness, which enables early mobilization in patients with fractures of the tibia bones (FTB) often experience a reduced quality of life and temporary disability, which can last from 8-10 weeks to 5-7 months or even up to 10-12 months for complex fractures. FTBs account for 13%-21.4% of all musculoskeletal injuries or 64.3%-70% of all lower limb fractures. The frequency of diaphyseal tibia bone fractures is 26-32 cases per 100,000 population. The injuries are typically the result of high-energy trauma and are often accompanied by severe soft tissue damage and comminuted fractures. The use of blocking intramedullary osteosynthesis has been shown to be highly effective in the surgical treatment of patients with meta-diaphyseal fractures of the tibia bones, with positive treatment outcomes in 96.66% of patients, providing biomechanically justified high stability of fixation and minimal trauma, allowing for early mobility and reducing the frequency of early and late postoperative complications.

Keywords: fractures, tibia bones, osteosynthesis

INTRODUCTION

In terms of the incidence of tibial bone fractures (TBF), they take the second place, accounting for 13% to 21.4% of all musculoskeletal injuries or 64.3%–70% of lower limb bone fractures [1, 2]. The frequency of diaphyseal TBF is 26–32 cases per 100,000 population [3]. As a rule, the nature of the injury is the result of high-energy trauma and is accompanied by severe damage to soft tissues and a multifragmentary type of fracture [4, 5]. The temporary incapacity for work in victims of TBF varies from 8–10 weeks to 5–7 months, and in case of complex fractures it reaches 10–12 months. [6, 7]. Treatment and early recovery of patients with unstable diaphyseal fractures of the tibia bone remain a relevant issue in modern traumatology. The difficulties in treating patients with ankle fractures, the complexity of their reduction, and the impossibility of stable fixation often lead to unsatisfactory treatment outcomes, which typically result in patient disability [8, 9]. Various methods of operative treatment are used for the treatment of ankle fractures, and there is no specific standard for the treatment of these fractures. In modern traumatology, preference is given to the method that provides rapid restoration of limb function, which is as close to physiological as possible. Some authors claim that interlocking intramedullary fixation is an effective method for treating patients with ankle fractures, while others prefer internal or external fixation methods [10, 11, 12, 13, 14, 15].

The aim of the study was to conduct a comparative analysis of the results of treatment of patients with fractures of the tibia bones and evaluate the effectiveness of different methods of osteosynthesis.

MATERIALS AND METHODS

The study analyzed the results of surgical treatment in 279 patients with tibial fractures who were treated at the Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine from 2016 to 2021. The study was conducted in accordance with the Helsinki Declaration and approved by the Ethics Committee of the Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine (protocol No. 4 of August 23, 2015). All patients signed informed consent to participate in this study.

Depending on the method of surgical treatment, the patients were divided into two groups. The main (experimental) group included 113 patients, mostly with diaphyseal tibial fractures, who underwent surgery with the use of blocking intramedullary osteosynthesis (BIOS). Among them, 45 patients had isolated fractures of the tibial bone, while in the other 68 patients, both tibial bones were affected.

The control group included 166 patients with tibial fractures who underwent osseous or transosseous osteosynthesis.

During the study of fracture types, the AO/ASIF classification was used, and the data is presented in Table 1.

Table 1. Types of fractures according to AO/ASIF classification.

Groups	Type of fractures according to AO classification			
	A	B	C	Overall
Main	34	58	21	113
Control	81	67	18	166
Overall	115	125	39	279

In the overall structure, 23.3% were females and 76.7% were males. The average age of the injured was 33.2 ± 14.3 years, and the majority of patients (74.6%) were in prime working age - up to 55 years old.

All the patients in the main group underwent surgical interventions using BIOS. All surgical procedures were performed using standard techniques. In most cases - 82 (72.6%), fracture reduction was closed or minimally invasive, without extensive exposure of the fracture area. In the remaining cases, it was necessary to open the fracture zone due to the interposition of soft tissues or the presence of fractures in the medullary canal. Widening of the medullary canal was performed according to the surgical technique. In all cases, an intramedullary nail was inserted from the trochanter of the femur. Compression fixation was performed in stable fractures, and static fixation was performed in unstable fractures.

Operative interventions were performed on the control group using osseous or transosseous osteosynthesis:

1. Metal-osteosynthesis (MOS) with LC/DCP plates in the majority of surgical interventions - 118 (71.1%) cases;
2. MOS with external fixation devices (EFD) was performed in 48 (28.9%) injured patients.

The choice of surgical treatment method depended on many factors:

- type of fracture according to the AO/ASIF classification;
- level of fracture (proximal/distal, central/peripheral, metaphyseal/diaphyseal);
- degree of soft tissue damage in the fracture area;
- the general condition of the patient (presence or absence of internal organ damage, multiple bone fractures).

Operative interventions on the control group's injured patients were performed using standard techniques. In the vast majority of cases, satisfactory repositioning of fractures was achieved with the use of external fixation devices (EFD), particularly in cases of distal tibia fractures with segmental or comminuted fractures of the fibula.

For all the patients with a fracture of the distal third of the fibula, and in some cases (in the case of segmental multifragmentary fractures of the tibia type C with the use of BIOS or EFD with the closed technique of fragment repositioning), MOS was performed with a plate with screws or an intramedullary rod/spike without blocking . Osteosynthesis of the fibula was performed in order to restore the length, rotation and axial relations, which is especially important for the distal segment of the tibia, as well as to facilitate the reposition of the tibial fragments.

Statistical analysis. Data processing was performed using Statistica 12 software (StatSoft, USA). Descriptive statistics methods were used to display the general characteristics of the input parameters, with mean values and standard deviations indicated. For groups with a normal distribution, comparisons were made using the Student's t-test. Using the $\chi 2$ test for statistical analysis, it was found that intergroup differences in patient age, gender, and injury severity, respectively, for the main and control groups, can be considered random ($p>0.1$). In other words, the groups were standardized for age and injury severity.

RESULTS OF THE RESEARCH

The high frequency of tibial bone fractures, as well as the effectiveness of modern treatment methods, are largely determined by anatomical features. For example, the position of the tibia at the level of the car bumper contributes to the fact that pedestrians are most often injured in collisions. Since one-third of the surface of the tibia is located under the skin for most of its length, open fractures occur more frequently than in other bones. Furthermore, the blood supply to the tibia is not as good as in bones surrounded by muscles on all sides. The presence of joint hinges on both ends of the bone does not allow for rotational and angular deformities to be ignored after a fracture, which requires special attention during reduction.

The small muscle mass and its absence on one-third of the surface make conservative treatment methods more effective in cases of stable tibial bone fractures. These same features make the ankle the most suitable segment for the use of internal fixation devices. Poor blood supply increases the risk of complications with the use of submerged osteosynthesis, while the ease of closed reduction promotes the wider use of minimally invasive techniques for internal fixation, especially intramedullary fixation.

The mentioned features of the occurrence and treatment of tibia bones fractures determine a high frequency of complications and efforts to avoid them by improving treatment methods [16, 17, 18].

In traumatology clinics, where the entire range of surgical treatment methods for the injured is applied, preference is given to methods that allow for:

- Obtaining the best anatomical and functional result;
- Reducing the frequency of early and late postoperative complications;
- Providing early patient activity and high quality of life throughout the treatment and rehabilitation period.

The analysis of the effectiveness of treatment of patients in the main and control groups is presented in Table 2.

Table 2. Basic indicators of treatment of patients in the main and control groups with tibial bones fractures

Indicators	Main group	Control group
Number of patients Mean age of patients	113 34,09 ± 14,13 years	166 37,28 ± 14,34 years
Postoperative bed-day Mean duration	from 2 to 78 days 11,72 ± 10,41 days	from 2 to 46 days 13,30 ± 6,45 days
Hospital stay Mean duration	from 4 д to 82 days 18,29 ± 11,71 days	from 3 to 63 days 20,23 ± 9,88 days
Dosage load Mean duration	from 0,2 to 10 weeks 1,82 ± 2,32 weeks	from 8 to 18 weeks 10,74 ± 1,89 weeks
Full load Mean duration	from 2 to 22 weeks 10,82 ± 2,95 weeks	from 8 to 35 weeks 17,94 ± 4,15 weeks
Fusion occurred Mean duration	from 8 to 22 weeks 11,56 ± 2,56 weeks	from 12 to 36 weeks 18,68 ± 4,70 weeks
Total treatment time Mean duration	from 8 to 22 weeks 14,44 ± 2,85 weeks	from 13 to 43 weeks 21,23 ± 5,38 weeks

Comparing the main indicators, we have established that the patients from the main group have significantly better results. The patients in the main group demonstrated significantly lower average figures for the postoperative bed-day and the average length of stay in the hospital. This is associated with the usage of minimally invasive methods and stable fixation, which allowed for avoiding external immobilization of the operated limb and enabled early functional rehabilitation, as well as measures to prevent adjacent joint contractures from the first days after the surgery. For instance, passive knee flexion up to 40^0 was achieved on the 7th day, and active flexion occurred 5 days later. Flexion mor than 100^0 (active and passive) was recommended after 2 weeks postoperatively.

Patients in the control group were only able to undergo early functional rehabilitation and preventive measures for adjacent joint contractures in the early postoperative period after external device fixation osteosynthesis (48 (28.9%)). The patients in the main group were recommended to perform controlled loading on the operated limb much earlier, within 0.2 to 10 (1.82 ± 2.32) weeks. Patients in the control group began axial loading only from 8 to 18 (10.74 ± 1.89) weeks after surgery. This is due to the longer period of primary callus formation and restructuring with ossification in the postoperative period during the restorative treatment.

The usage of minimally invasive methods of stable fixation for the patients in the main group, the possibility of early functional rehabilitation, and the implementation of preventive measures for adjacent joint contractures from the first days, as well as the possibility of early controlled loading on the operated limb, resulted in a reduction in the time of fusion of the tibial bone fractures and shorter overall treatment time. Callus fusion was observed in the main group of patients from 8 to 22 (11.56 ± 2.56) weeks, and in the control group from 12 to 36 (18.68 ± 4.70) weeks.

The overall treatment duration for patients in the main group ranged from 8 to 22 (14.44 ± 2.85) weeks, while for those in the control group it was from 13 to 43 (21.23 ± 5.38) weeks. The results of treatment for tibia bone fractures in patients in the main and control groups are presented in Table 3.

Table 3. Results of treatment in patients of the main and control groups

Result of treatment	Main group	Control group		
	BIOS	External fixation device	LC/DCP plates and screws	Overall
Excellent and good	91 (80,53%)	34 (70,83%)	81 (68,65%)	206 (73,83%)
Satisfactory	18 (15,93%)	12 (25,00%)	26 (22,03%)	56 (20,07%)

Unsatisfactorily	4 (3,54%)	2 (4,17%)	11 (9,32%)	17 (6,10%)
Overall	113 (100%)	48 (100%)	118 (100%)	279 (100%)

Excellent and good treatment results were obtained in 80.53% of patients in the main group, whereas in the control group, this indicator ranged from 68.65% to 70.83%.

Satisfactory and unsatisfactory treatment results were obtained in most cases in the control group. Thus, satisfactory results were obtained in 38 (47.03%) of the control group patients, and unsatisfactory results were obtained in 13 (13.49%) cases. This is due to the development of neurotrophic disorders, contractures of adjacent joints, non-union, fixation device fractures, and the development of osteomyelitis.

DISCUSSION

In recent decades, intermedullary osteosynthesis has been widely used in traumatology practice. This method provides rigid fixation of bone fragments, even in cases where other technologies cannot be used. This is primarily true for open fractures of the II-III degree. Compression, distraction, or prolonged fixation of fragments in a neutral position is only possible with intermedullary osteosynthesis. The method is indispensable as a means of temporary fixation of tibial bones fractures in patients with polytrauma, with the development of compartment syndrome. One of the main problems of intermedullary osteosynthesis, even in the case of tibial bones fractures, remains inflammatory complications in the area of the elements of the external fixation devices, which are noted in 10.5% to 51.3% of cases and often end up with osteomyelitis [19].

Traditional plate osteosynthesis was the method of choice for tibial bones fractures without significant soft tissue damage until the introduction of BIOS. Currently, MIPO (minimally invasive plate osteosynthesis) with plates is widely used for treating ankle fractures. The main goal of this method is to preserve tissue viability in the fracture zone. The popularity of MIPO is due to changes in plate design, including the development of "internal fixators" that block screws in plate holes. Plate designs are optimized for each location and type of fracture. For example, T. Müller et al. [20] reported on the effectiveness of this method in 85% of patients with fractures of the distal tibia. E. Hasenboehler et al. [21] conducted a retrospective study of patients with ankle fractures over 2 years. Good results were obtained in 31.3% of cases after 3 months of MIPO surgery, in 71.9% after 6 months, and in 84.4% after 9 months.

In the main group, only 4 cases (3.54%) resulted in unsatisfactory outcomes. In one patient, after 24 weeks following the surgery, a fistula in the area of the fracture opened, which healed after removing the fixator. In two other patients, non-union with migration of the fixators and subsequent fracture of the intramedullary rod was observed. Additionally, in one case, an early postoperative complication was noted, which was an infection of the surgical site that required wound revision, removal of metal fixators, and a change in the fixation method.

CONCLUSION

1. The use of locking intramedullary osteosynthesis has proven to be *highly effective in the surgical treatment of patients with metaphyseal fractures* of the tibia and allowed for positive treatment outcomes in 96.66% of patients.
2. The advantage of locking intramedullary osteosynthesis is biomechanically justified high stability of fixation, low invasiveness, which allows early activity of patients and high quality of life throughout the treatment and rehabilitation period; as well as reduce the frequency of early and late postoperative complications.

CONFLICT OF INTEREST AND FINANCIAL SUPPORT

The authors have no conflict of interest to declare and no financial support in obtaining the results and writing this article.

AUTHOR CONTRIBUTIONS

AK worked at concept and design of the study, analysis of data acquisition. YuL collected and processed materials, analyzed research data and structured the text. YuS collected and analyzed literary sources, carried out patient selection, statistical research. VP analyzed the research results.. NK collected and analyzed literary sources, carried out statistical research and text formatting. YeS wrote and edited the manuscript.

REFERENCES

1. Elsoe R, Larsen P, Nielsen NP, Swenne J, Rasmussen S, Ostgaard SE. Population based epidemiology of tibial plateau fractures. Orthopedics. 2015;38(9):e780-6. DOI: 10.3928/01477447-20150902-55
2. Court-Brown CM, Duckworth AD, Clement ND, McQueen MM. Fractures in older adults. A view of the future? Injury. 2018;49(12):2161-6. DOI: 10.1016/j.injury.2018.11.009
3. Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. Incidence and epidemiology of tibial shaft fractures. Injury. 2015;46(4):746-50. doi: DOI: 10.1016/j.injury.2014.12.027
4. Mcmurtry J, Mounasamy V. Segmental tibia fractures. Ann Orthop Rheumatol 2015;3(3):1051.
5. Winkler D, Goudie ST, Court-Brown CM. The changing epidemiology of open fractures in vehicle occupants, pedestrians, motorcyclists and cyclists. Injury. 2018;49(2):208-12. doi: DOI: 10.1016/j.injury.2017.11.009
6. Connelly CL, Bucknall V, Jenkins PJ, Court-Brown CM, McQueen MM, Biant LC. Outcome at 12 to 22 years of 1502 tibial shaft fractures. Bone Joint J. 2014;96-B(10):1370-7. DOI: 10.1302/0301-620X.96B10.32914
7. Henkelmann R, Frosch KH, Glaab R, Lill H, Schoepp C, Seybold D et al. Infection following fractures of the proximal tibia - a systematic review of incidence and outcome. BMC musculoskeletal disorders. 2017;18(1):481. DOI: 10.1186/s12891-017-1847-z.
8. Fong K, Truong V, Foote CJ, Petrisor B, Williams D, Ristevski B et al. Predictors of nonunion and reoperation in patients with fractures of the tibia: an observational study. BMC musculoskeletal disorders. 2013;14:103. DOI: 10.1186/1471-2474-14-103
9. Kugelman D, Qatu A, Haglin J, Leucht P, Konda S, Egol K. Complications and unplanned outcomes following operative treatment of tibial plateau fractures. Injury. 2017;48(10):2221-9. DOI: 10.1016/j.injury.2017.07.016
10. Dickson D, Moulder E, Hadland Y, Giannoudis P, Sharma H. Grade 3 open tibial shaft fractures treated with a circular frame, functional outcome and systematic review of literature. Injury. 2015;46:751-58. DOI: 10.1016/j.injury.2015.01.025
11. Minhas SV, Ho BS, Switaj PJ, Ochenjele G, Kadakia AR. A comparison of 30-day complications following plate fixation versus intramedullary nailing of closed extra-articular tibia fractures. Injury. 2015;46(4):734-9. DOI: 10.1016/j.injury.2014.12.014
12. Costa ML, Achten J, Griffin J, Petrou S, Pallister I, Lamb SE et al. Effect of locking plate fixation vs intramedullary nail fixation on 6-month disability among adults with displaced fracture of the distal tibia: the uk fixdt randomized clinical trial. JAMA. 2017;318(18):1767- 76. DOI: 10.1001/jama.2017.16429
13. Khan MS, Giacomo L, Bisaccia M, Azzam W, Jatoi A, Rollo G, Meccariello L. Ilizarov technique, satisfactory outcome with limited resources. Clin Cases Miner Bone Metab. 2018;15:221–6.
14. Seron S, Rasool MN. Outcomes of intramedullary nailing for open fractures of the tibial shaft. SA Orthop J 2018;17(1):24-29. DOI:10.17159/2309-8309/2018/v17n1a3
15. Morris R, Pallister I, Trickett RW. Measuring outcomes following tibial fracture. Injury. 2019;50(2):521-33. DOI: 10.1016/j.injury.2018.11.025
16. Andalib Z., Sheikhbahaei E., Mohammad A. Tahririan Effectiveness of Minimally Invasive Plate Osteosynthesis (MIPO) on Comminuted Tibial or Femoral Fractures // Arch Bone Jt Surg. 2017 Sep; 5(5): 290–295.
17. Bingol I, Yalcin N, Bicici V, Tulunay T. Minimally invasive percutaneous plate osteosynthesis does not increase complication rates in extra-articular distal tibial fractures // The Open Orthopaedics Journal, 2015, 9, 73- 77. DOI:10.2174/1874325001509010073
18. Khayas K, Arun K, Ravikumar V. Outcome of regular nailing in fracture of proximal third tibial shaft // International Journal of Orthopaedics Sciences 2016; 2(3): 142-148.
19. Menakaya C.U., Rigby A.S., Hadland Y., Barron E., Sharma H. Fracture healing following high energy tibial trauma: Ilizarov versus Taylor Spatial Frame Hull and East Yorkshire Hospitals NHS Trust, UK University of Hull, UK. Ann R Coll Surg Engl. 2014 Mar; 96(2): 106–110. DOI: 10.1308/003588414X13824511650335
20. Müller T, Sommer C. Minimally invasive plate osteosynthesis of the distal tibia. Oper. Orthop. Traumatol. 2012. Vol. 24, No 4-5. P. 354-367. DOI: 10.1007/s00064-012-0169-4
21. Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. Injury. 2007. Vol. 38, No 3. P. 365-370. DOI: 10.1016/j.injury.2006.10.024

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