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Complex Surgical Treatment of an Open Fracture of the Distal End of the Shin Bones (Literature Review)

Eldor M. Khamdamov
Doctor of the traumatology center for combined injuries and acute vascular diseases of the Ishtikhan Medical Association, Ishtikhan, Uzbekistan
Shavkat N. Ravshanov
PhD, head of the department of hand and foot surgery of the republican specialized scientific and practical center of traumatology and orthopedics, Tashkent, Uzbekistan

Abstract: Treatment of fractures of the shin bones remains one of the most important problems not only in traumatology, but also in a number of related specialties. The duration of treatment of victims varies widely: from 3-4 months with closed tibial fractures without displacement to 5-7 months in cases of open injuries. With complicated fractures, they often reach 9-10 months or more. In the structure of disability, fractures of the lower leg occupy a leading place and account for 7.0–37.6% of all injuries of the musculoskeletal system.

Keywords: open fracture, shin bones, osteosynthesis, external fixation, immobilization.

The purpose of the study: To analyze the world literature on complex surgical treatment of an open fracture of the distal end of the shin bones.

The problem of treating patients with open fractures of the shin bones is considered one of the most urgent in traumatology and orthopedics. The interest in it is beyond doubt and is due to a number of reasons, in particular, the predominance of open fractures of the lower leg among open fractures of other localization, in industrial society, open fractures of the lower leg occur with a frequency of 2 cases per 1000 injuries per year, that is, they account for 0.2% of all injuries. Fractures of the tibial diaphysis occur in 17-21 per 100000 cases. of the population per year, account for 2% of all fractures and 36.7% of all long bone fractures in adults.

According to F. Behrens et al., in an industrial society, the incidence of open fractures of the lower leg is two cases per 1000 injuries per year, that is, 0.2% of all injuries. In developing countries, the frequency and severity of damage is probably higher. Fractures of the tibial diaphysis occur in 17-21 cases per 100 thousand people per year, account for 2% of all fractures and 36.7% of all open fractures of long bones in adults [7, 61]. According to C. Court-brown et al., tibial fractures are the most frequent fractures of long bones. Since the tibia is located directly under the skin, most of its fractures are open [1].

The main causes of open fractures of the lower leg are road traffic accidents, falls from a height, injuries while skiing and falls. The mechanism of injury determines the configuration of the fracture (for example, ski injuries usually lead to spiral fractures). In most cases, fractures are multi-fragmented [2, 3, 4].

It is not only the prevalence that determines the high importance of open tibial fractures as a medical and social problem. the main reasons are the temporary and persistent disability of the victims for a long time, the high frequency of complications and their consequences, the inability to preserve the limb and the need for amputation in a certain percentage of cases, expensive high–tech treatment, prolonged hospitalization and rehabilitation.

With injuries to the lower extremities, the percentage of recovery of working capacity with a return to previously performed work is 49-53% [5].

The type of fracture is reliably prognostically significant for all outcome parameters, except self-service.

According to C. Court-Brown et al., tibial fractures are the most frequent fractures of long bones [6].

It is characteristic that open fractures of the tibia are mainly the result of high-energy traumatic effects, while gross damage to the bone and surrounding tissues occurs, which significantly worsens the prognosis in the treatment of the damaged segment.

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Classifications of open fractures of the lower leg

The creation of a unified classification of open tibial fractures is very important for determining the optimal treatment tactics. In Russia, the most popular classification of open fractures was proposed by A.V. Kaplan and O.V. Markova in 1968 [7], in which the authors divided open fractures into three types, depending on the size of the skin wound and the cause of its occurrence (punctured, chopped, bruised). A separate group identified IV types of injury, reflecting impaired limb viability. This classification is very good for analyzing the nature of damage, but does not reflect the degree of damage to soft tissues and is quite difficult for practical use.

Another classification proposed by F.R. Bogdanov [8] divides open fractures into four degrees: mild, moderate, severe and very severe. The proposed classification is extensive, insufficiently clear and does not help much in choosing treatment tactics.

The most interesting and convenient for practical application is the classification proposed by I.F. Bialik [9], according to which open fractures are divided into four groups according to the nature of the injury and the type of surgical treatment of the wound. The first group includes wounds with a small area of damage that can be sewn up freely without skin tension. To the second – wounds with an average zone of damage, detachment of soft tissues, for the closure of which it is necessary to perform laxative incisions. The third group includes wounds with a large area of damage, which require skin plastic surgery to close. And finally, the fourth group includes wounds with severe soft tissue damage with impaired limb viability and traumatic amputations. The presented classification is convenient for practical application and focuses the attention of doctors on the method of surgical closure of a skin wound, and not on the tactics of treating an open fracture.

In the world literature, the Gustilo–Andersen classification is generally accepted [10, 11]. According to this classification, open fractures are divided into 3 groups:

I – group: A wound from exposure to low energy, up to 1 cm long, is more often formed by the action of the bone from the inside to the outside, rather than from an external injury. In type I wounds, muscle damage is minimal or completely absent;

II – group: A wound from exposure to high energy, length more than 1 cm, is formed from a rupture of the skin. There are areas of muscle necrosis, but the damage is localized within one fascial case. There is no detachment of soft tissues from the bone or it is minimal.

III – group: Occurs from exposure to high energy, skin damage – from outside to inside, the size of the wound is more than 10 cm with an extensive area of muscle necrosis.

IIIA - Limited detachment of the periosteum and soft tissues from the bone, closing the bone with soft tissues does not cause big problems. Usually, the soft tissue cover in the fracture area is quite well preserved.

IIIB - Extensive detachment of soft tissues and periosteum from the bone is observed; necrosis and loss of soft tissues requires replacement with a local flap or a free tissue graft to close the wound.

IIIC - Damage to large vessels requiring restoration of their integrity to preserve the limb.

Thus, according to C. Court-Brown et al., 56.9% of open tibial fractures (n=230) were of type III, while there was a positive correlation between the severity of the fracture according to the Gustilo-Andersen classification and the frequency of infectious complications, long hospitalization periods, a large number of operations and longer- solid consolidation [6].

The frequency of infectious complications is 0-2% in type I, 2-7% in type II, 7% in type IIIA, 10-50% in type IIIB and 25-50% in type IIIC (amputation rate of 50% or more), while the overall frequency of infectious complications in type III fractures is 10-25%. With fractures of type III, the risk of infection is 3.5 and 2.5 times higher than with fractures of type I and II, respectively [12].

The majority of open tibial fractures are diaphyseal, of which 60% are type III according to Gustilo–Andersen. In the work of C. Papakostidis et al. the analysis of 32 publications containing data on 3060 cases of open fractures of the lower leg in 3036 patients was carried out [13]. There were 527 type I fractures, 1779 type II fractures and 1754 type III fractures, with type IIIA observed in 643 cases (37.9%), type IIIb in 790 (46.5%) and type IIIc in 247 (14.5%).

P.V. Giannouids et al. the relationship between the quality of life of patients in the catamnesis and the severity of the fracture according to Gustilo–Andersen was studied [14]. Thus, the frequency and severity of

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anxiety, depression, problems with daily activity, self-care and mobility were experienced mainly by patients with IIIb-with types of fracture and after amputations.

Tactics and technologies of osteosynthesis in open fractures of the lower leg

Treatment of fractures of the shin bones remains one of the most important problems not only in traumatology, but also in a number of related specialties. The duration of treatment of victims varies widely: from 3-4 months with closed tibial fractures without displacement to 5-7 months in cases of open injuries. With complicated fractures, they often reach 9-10 months or more. In the structure of disability, fractures of the lower leg occupy a leading place and account for 7.0–37.6% of all injuries of the musculoskeletal system.

Options for stabilizing bone fragments include immobilization in plaster, out-of-focus fixation and internal fixation with plates and intramedullary rods [15,16,17].

For the present, there is no single point of view on the method of fixing open fractures of the shin bones. The main discussions take place between supporters of intramedullary osteosynthesis without drilling of the medullary canal and transosseous compression-distraction osteosynthesis (TCDO) by Ilizarov or external fixation devices (EFD) [18, 19].

In patients with proximal tibial fractures, good results were obtained when using bone osteosynthesis with a plate. fractures of the distal end of the shin bones present a much greater difficulty in choosing the method of osteosynthesis.

Some authors recommend primary stabilization using semi-root systems of external fixation or osteosynthesis with a plate, while others support primary or delayed intramedullary osteosynthesis even in fractures of types IIIb-c.

According to S. Kakar and P. Tornetta, thorough surgical treatment of the wound and immediate fixation by intramedullary osteosynthesis without drilling the canal is a safe and effective tactic for the treatment of patients with open fractures of the tibia I-IIIb types. deep infection among patients treated according to the developed protocol was observed in 3% of cases, and the incidence of implant failure was lower than in the published patient series. In general, patients were satisfied with the results of treatment, but about 41% of patients complained of pain in the knee area or fracture zone after consolidation [20].

K. Yokoyama et al. It was shown that with immediate intraosseous osteosynthesis, the frequency of deep infection in fractures of types IIb-c was significantly higher than in types I-IIIA. Non-fusion was observed in 20.3% of cases. The severity of the gustilo–Andersen fracture and the frequency of deep infection clearly correlated with the duration of consolidation. In addition, immediate intraosseous osteosynthesis in type IIIb-c is associated with a potential risk, however, channel re-drilling did not increase the risk of complications [21].

In the work of M.R. Brinker et al. it is shown that when the channel is re-drilled, the feeding artery of the tibia is damaged to a much greater extent than without it, and the effect of re-drilling manifests itself in a period of up to two weeks. E.H. Schemitsch et al. it was found that when the channel was re-drilled, there was a more pronounced decrease in the porosity of the cortical bone, as well as a significant overall decrease in endosteal perfusion immediately after surgery; this phenomenon persisted up to 12 weeks after re-drilling and up to 6 weeks without it. According to the literature, when drilling the channel, the frequency of incorrect fusion is significantly lower than without it or when using external fixation [22].

L.X. Webb et al. It was recommended to abandon external fixation in type Iii fractures in favor of intramedullary rods. Intramedullary osteosynthesis in open tibial fractures is part of the concept of early soft tissue reconstruction (“x and ap"). In his article S. gopal et al. early soft tissue reconstruction in combination with intramedullary osteosynthesis in IIIb type fractures was recommended [23].

Intramedullary osteosynthesis without channel drilling is widely used in open fractures of the lower leg bones. The frequency of deep infection and non-fusion in fractures of I, II and III types with this type of fixation is lower than with other types of fixation. The risk of deep infection does not increase with intramedullary osteosynthesis. In addition, the use of intramedullary rods instead of external systems eliminates the risk of infection caused by transosseous conduction of rods.

However, the approach to the treatment of type IIIb fractures using intramedullary osteosynthesis is ambiguous. According to P. Tornetta et al., the convenience of access to soft tissues when using external fixation systems determines their advantage over intramedullary rods [20].

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G.A. Ilizarov et al. showed that during distraction of fragments, there was no rupture of the anastomosis site during reconstruction of large vessels [24]. The combination of Ilizarov TCDO and tissue transplantation is possible due to a number of biological and mechanical factors. Well-vascularized soft tissues provide a sufficient level of blood supply for the eradication of infection and successful bone fusion. improved blood supply also contributes to the delivery of antibiotics. Ilizarov TCDO provides biological stimulation of bone tissue growth and the necessary stable conditions.

Since open fractures of the lower leg are often found as an element of multiple and combined injuries, the question of the order and stage of surgical treatment is relevant [25]. In the works of I.S. Abdusalamov and S.A. Radkevich, it was convincingly demonstrated that simultaneous fixation of fractures of several segments improves treatment outcomes [16, 26]. The treatment of open fractures in multiple and combined trauma is based on early osteosynthesis of open and dominant closed fractures of long bones and pelvic bones, which is an important part of the complex of therapeutic measures in the acute period of traumatic illness. With a stable functional state of the patient, operations for multiple and combined fractures (in the cases shown) should be performed in the first three days after the injury (during the period of relative stabilization of impaired functions). By the end of this period, it is necessary to complete the stabilization of all open and dominant closed fractures of the bones of the extremities and pelvis [27, 28].

It is necessary to emphasize the ambiguity of each opinion expressed in the published works. With regard to the choice of the method of osteosynthesis in open tibial fractures, determining the timing of the change of fixators and other key issues, the literature provides a variety of points of view.

Conclusions:

The analysis shows a constant search for new approaches to the development and improvement of existing devices for the treatment of patients with diaphyseal fractures of the lower leg bones. The problem is still relevant. In order to eliminate the shortcomings and optimize both the reposition and fixation systems, in our opinion, it is necessary to conduct further searches aimed at more rational scientifically-based fixation schemes and more effective use of external fixation devices.

Competing interests:

The authors declare that they have no competing interests.

References

1. Avazashvili, N., & Sakhvadze, S. (2020). Tactics of Open Fracture Treatment. *COLLECTION OF SCIENTIFIC WORKS OF TBILISI STATE MEDICAL UNIVERSITY*, *54*.
2. Тиляков, А. Б., Тиляков, Х. А., Ташходжаев, А. А., & Мирзаев, А. К. (2019). Результаты блокирующего интрамедуллярного остеосинтеза при диафизарных переломах костей голени. *Вестник экстренной медицины*, *12*(1), 40-42.
3. Набиев, Е. Н., Тезекбаев, К. М., Альходжаев, С. С., Тусупуов, Д. М., Турбеков, Н. А., Жаксымуратов, М. З., ... & Тлеуназаров, Б. Б. (2020). ЛЕЧЕНИЕ ПЕРЕЛОМОВ КОСТЕЙ КОНЕЧНОСТЕЙ И ТАЗА ПРИ ПОЛИТРАВМЕ. *Вестник Казахского Национального медицинского университета*, (1), 305-307.
4. Elniel, A. R., & Giannoudis, P. V. (2018). Open fractures of the lower extremity: Current management and clinical outcomes. *EFORT open reviews*, *3*(5), 316-325.
5. Токтаров, Е. Н., Жанаспаев, М. А., Тлемисов, А. С., Джунусов, Т. Г., Мысаев, А. О., & Касымов, К. Т. (2018). Лечение диафизарных переломов костей голени. Обзор литературы. *Наука и здравоохранение*, (6), 58-69.
6. Winkler, D., Goudie, S. T., & Court-Brown, C. M. (2018). The changing epidemiology of open fractures in vehicle occupants, pedestrians, motorcyclists and cyclists. *Injury*, *49*(2), 208-212.
7. Mitish, V. A., Ushakov, A. A., Borisov, I. V., & Ivanov, A. P. (2020). Shin both bones open fracture, complicated by purulent infection, complex surgical treatment. *Wounds and wound infections. The prof. BM Kostyuchenok journal*, *5*(3), 25-39.

8. Багиров, А. Б., Цискарашвили, А. В., Шестерня, Н. А., Иванников, С. В., Жарова, Т. А., & Суварлы, П. Н. (2018). Наружный остеосинтез при переломах длинных костей нижних конечностей. *Политравма*, (3).
9. Анкин, Н. Л., Петрик, Т. М., Ладыка, В. А., & Продусевич, Л. В. (2018). Оценка динамики показателей течения воспалительного процесса у пациентов с открытыми переломами костей голени. *Хирургия. Восточная Европа*, *7*(3), 317-325.
10. Bankhead-Kendall, B., Gutierrez, T., Murry, J., Holland, D., Agrawal, V., Almahmoud, K., ... & Truitt, M. S. (2019). Antibiotics and open fractures of the lower extremity: less is more. *European Journal of Trauma and Emergency Surgery*, *45*(1), 125-129.
11. Васюков, В. А., Оганджанян, К. К., & Исаева, А. В. (2019). НАШ ОПЫТ ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ ПЕРЕЛОМОВ ДЛИННЫХ ТРУБЧАТЫХ КОСТЕЙ У ДЕТЕЙ И ПОДРОСТКОВ В УСЛОВИЯХ ТРАВМАТОЛОГО-ОРТОПЕДИЧЕСКОГО ОТДЕЛЕНИЯ ГБУЗ СК «КРАЕВАЯ ДЕТСКАЯ КЛИНИЧЕСКАЯ БОЛЬНИЦА» Г. СТАВРОПОЛЬ. *ббК 54.58 Е 36*, 77.
12. Селицкий, А. В., & Кезля, О. П. (2020). Алгоритм лечения сложных сегментарных и многооскольчатых диафизарных переломов большеберцовой кости. *Известия Национальной академии наук Беларуси. Серия медицинских наук*, *17*(3), 287-300.
13. Papakostidis, C., & Giannoudis, P. V. (2021). Femoral shaft fractures. *Evidence-Based Orthopedics*, 589-594.
14. Дюсупов, А. З., Дюсупов, А. А., Манарбеков, Е. М., Букатов, А. К., & Серикбаев, А. С. ЧРЕСКОСТНЫЙ ОСТЕОСИНТЕЗ ПЕРЕЛОМОВ КОСТЕЙ НИЖНИХ КОНЕЧНОСТЕЙ И КАЧЕСТВО ЖИЗНИ БОЛЬНЫХ В ПЕРИОД ЛЕЧЕНИЯ. *GEORGIAN MEDICAL*, 22.
15. Tutton, E., Achten, J., Lamb, S. E., Willett, K., & Costa, M. L. (2018). A qualitative study of patient experience of an open fracture of the lower limb during acute care. *Bone Joint J*, *100*(4), 522-526.
16. Тухтакулов, А. Ю., Махмудов, Н. И., Дехканов, К. М., Ботиралиев, А. Б., & Тожиев, М. М. (2021). СОВРЕМЕННЫЕ ПОДХОДЫ К ПРИМЕНЕНИЮ МАЛОИНВАЗИВНЫХ ОПЕРАТИВНЫХ МЕТОДОВ ЛЕЧЕНИЯ БОЛЬНЫХ С ПОЛИТРАВМАМИ В ФЕРГАНСКОМ ФИЛИАЛЕ РНЦЭМП. *Вестник экстренной медицины*, *14*(6), 20-23.
17. Дюсупов, А. А., Букатов, А. К., Серикбаев, А. С., Манарбеков, Е. М., Дюсупова, А. А., Дюсупов, А. З., & Джумабеков, С. А. (2018). Оценка качества жизни больных в период лечения переломов костей нижних конечностей чрескостным остеосинтезом. *Наука и здравоохранение*, (6), 98-107.
18. Matsumura, T., Takahashi, T., Miyamoto, O., Saito, T., Kimura, A., & Takeshita, K. (2019). Clinical outcome of conversion from external fixation to definitive internal fixation for open fracture of the lower limb. *Journal of Orthopaedic Science*, *24*(5), 888-893.
19. Беленький, И. Г., Кочиш, А. Ю., Майоров, Б. А., Обухов, П. А., Усенов, М. Б., Григорян, Ф. С., & Демьянова, К. А. (2020). Анализ структуры переломов дистального метаэпифиза большеберцовой кости и лодыжек в городском многопрофильном стационаре. *Современные проблемы науки и образования*, *1*, 79.
20. Kuripla, C., Tornetta III, P., Foote, C. J., Koh, J., Sems, A., Shamaa, T., ... & Lipof, J. (2021). Timing of flap coverage with respect to definitive fixation in open tibia fractures. *Journal of Orthopaedic Trauma*, *35*(8), 430-436.
21. Yokoyama, K., Shindo, M., Itoman, M., Yamamoto, M., & Sasamoto, N. (1994). Immediate internal fixation for open fractures of the long bones of the upper and lower extremities. *The Journal of trauma*, *37*(2), 230-236.
22. Atwan, Y., & Schemitsch, E. H. (2020). The top three unanswered questions in the management of open fractures. *OTA International*, *3*(1).
23. Webb, L. X., Dedmond, B., Schlatterer, D., & Laverty, D. (2006). The contaminated high-energy open fracture: a protocol to prevent and treat inflammatory mediator storm-induced soft-tissue compartment syndrome (IMSICS). *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, *14*(10), S82-S86.
24. Gubin, A. V., Borzunov, D. Y., & Malkova, T. A. (2013). The Ilizarov paradigm: thirty years with the Ilizarov method, current concerns and future research. *International orthopaedics*, *37*(8), 1533-1539.

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Date of Publication:30-05-2022

25. You, D. Z., & Schneider, P. S. (2020). Surgical timing for open fractures: Middle of the night or the light of day, which fractures, what time?. *OTA International*, *3*(1).
26. Diwan, A., Eberlin, K. R., & Smith, R. M. (2018). The principles and practice of open fracture care, 2018. *Chinese Journal of Traumatology*, *21*(04), 187-192.
27. Rittstieg, P., Wurm, M., Müller, M., & Biberthaler, P. (2020). Current treatment strategies for lower leg fractures in adults. *Der Unfallchirurg*, *123*(6), 479-490.
28. Milenkovic, S., Mitkovic, M., & Mitkovic, M. (2020). External fixation of segmental tibial shaft fractures. *European Journal of Trauma and Emergency Surgery*, *46*(5), 1123-1127.