

Use of high-intensity laser for prevention and treatment of osteomyelitic complications in patients with traumatic disease

Stepan S. Filip, Rudolf M. Slivka, Yuriy P. Skrypynets, Petro P. Popyurkanych, Andrii M. Bratasiuk
UZHGOROD NATIONAL UNIVERSITY, UZHGOROD, UKRAINE

ABSTRACT

Aim: To improve the results of treatment of patients with osteomyelitis on the background of traumatic disease.

Materials and Methods: A retrospective evaluation of the treatment of 29 patients with chronic post-traumatic osteomyelitis of the bones of the lower extremities on the background of a traumatic disease.

Results: As a result of the treatment, an acceleration of the dynamics of the wound process was observed in patients of the second group, which was manifested in a reduction in the healing time of fistulas. Radiologically, reparative changes and acceleration of bone regeneration were noted on the 22nd-23rd day after the injury, the formation of a primary bone callus in patients of the control group occurred on the 32nd-35th day after the injury.

Conclusions: The use of methods for the prevention and treatment of osteomyelitic complications in long bone fractures, using high-intensity laser radiation against the background of regional intra-arterial infusions, with correction of the state of "chronic stress", allows accelerating the dynamics of the wound process and bone regeneration, and achieving rapid restoration of working capacity in most patients.

KEY WORDS: traumatic disease, chronic stress, chronic post-traumatic osteomyelitis, clinical course, immunity

Wiad Lek. 2025;78(9):1746-1750. doi: 10.36740/WLek/212505 DOI

INTRODUCTION

Current events that are taking place in Ukraine today formulate special requests both to medical science in general and to the tactics of treating certain traumatic injuries in particular, especially in traumatic disease. Traumatic disease greatly affects the outcome of the injury, determines the prognosis for the course of the pathological process, the results of treatment and work capacity. Of great importance are changes in the psycho-emotional sphere, metabolic and homeostatic processes, the state of the immune system, the functioning of the heart, lungs, digestive organs and the central nervous system [1-4].

The traumatic agent of today (mine and explosive injury), having a large mass and significant acceleration, leads to massive damage to soft tissues and bones not only at the site of direct contact, but also at a considerable distance. Another significant factor that affects the results of treatment of these patients is bacterial contamination of wounds during trauma.

Due to the increase in the proportion of trauma in the overall structure of morbidity, against the background of the evolution of purulent infection towards new antibiotic-resistant strains and the weakening of the human body's resistance, the proportion of

postoperative osteomyelitis after osteosynthesis of closed fractures does not decrease. The widespread use of surgical methods to align bone fragments by metal osteosynthesis has led to an increase in the number of operations, and this has led to an increase in the proportion of osteomyelitic complications from up to 8-10% [5,6,7,8].

Osteomyelitis occupies one of the most dramatic pages of world medicine. Early, compared with other pathologies, disability defines the problem of osteomyelitis as one of the main priorities of national health care systems. In persons with open fractures of the long bones of the lower extremities, the frequency of osteomyelitis is 10.3-20.4% and tends to increase, while in 15-30% of patients the process passes into a chronic stage. In the overall structure of disability due to musculoskeletal injuries, the share of osteomyelitis is 15% [9-12].

Despite scientific and practical achievements and successes in the prevention and treatment of this serious bone pathology, relapses are observed in 10-40% of cases. Long-term disability of this category of patients and high disability rates give the problem of medical and social importance [13,14].

The search for early measures for the prevention and treatment of osteomyelitic complications, which

would be combined with bone-plastic reconstructive operations, is justified. In particular, the use of minimally invasive sanitizing laser measures makes it possible to prevent the development of infectious complications and avoid prolonged antibiotic therapy in the treatment of patients exhausted by «traumatic stress.»

AIM

To improve the results of treatment of patients with osteomyelitis on the background of traumatic disease.

MATERIALS AND METHODS

On the basis of the surgical department of the KNP «Uzhgorod City Multidisciplinary Clinical Hospital» of the Uzhgorod City Council of the SE «Clinical Hospital of Planned Treatment» for the period from 2022 to 2025, 29 patients with chronic post-traumatic osteomyelitis of the bones of the lower extremities on the background of a traumatic disease were treated. In 13 (44.8%) patients in the treatment complex, along with the regional administration of bone-tropic antibacterial, vasodilator, analgesic, and immunostimulating drugs, minimally invasive surgical interventions (treatment of fistula passages, treatment of sequestral cavities, sequestrectomy, sequestrotomy) using high-intensity laser radiation were used.

The age of the patients ranged from 25 to 65 years; there were 23 men (79.3%), 6 women (20.7%). In 25 (86.2%) patients, chronic post-traumatic osteomyelitis of the tibia was diagnosed, and in 4 (13.8%) – of the femur.

The patients were divided into two groups. The first group included 16 (55.2%) patients who received standard treatment, which consisted of sanitation of the focus of the purulent-necrotic process, antibacterial, detoxification and vascular therapy, which was carried out intravenously and intramuscularly.

In the treatment of the second, main group of patients, 13 (44.8%) patients, the method of regional administration of antibacterial and vascular drugs by intraarterial puncture (through the femoral artery) was used. Antibacterial therapy was carried out taking into account the sensitivity of microorganisms; preference was given to osteotropic drugs.

It should be noted that the dominant pathogen was *Staphylococcus aureus*, which was detected in 14.2% of cases as a monoculture and in 85.8% in association with other pathogens, *Escherichia coli* was present in 27.6% of cases, *Pseudomonas aeruginosa* – 17.2%, *Proteus* – 12.6%, *Streptococcus* – 10.4%. In 63.5% of cases, mixed flora was sown.

The aim of the surgical intervention was to eliminate the osteomyelitic focus without the use of large traumatic surgical accesses using a source of high-intensity infrared laser radiation «Lika-hirug» and a quartz-polymer monofiber light guide inserted through the skin or fistula passage under the control of X-ray examination methods, during which laser treatment of fistula passages, sequestral cavities, vaporization of individual sequestrs and the surgical wound with high-intensity laser radiation was performed using a source with a power of up to 10 W and a wavelength of 940 nm. When installing the appropriate metal fixators, careful processing was performed, both the edges of the bone fragments and the entire surgical wound.

For the purpose of fixing bone fragments, rod-type external fixation devices (Ex Fix) were used.

During the study, the dynamics of the wound process, radiological dynamics, endogenous intoxication indicators by the level of medium molecular peptides (MMP), indicators of the body's immune defense by the ratio of T-helpers to T-suppressors, indicators of humoral immunity by the level of circulating immune complexes (CICs) were evaluated. The results obtained were compared with a group of clinically healthy people who were matched by age and gender.

Patients in the second group were treated with anti-stress drugs, adaptogens, and medications that correct the level of cortisol in the body, which is an integral part of immunotherapy.

The effectiveness of treatment was assessed by the degree of severity of general and local signs of inflammatory reaction, the dynamics of bone wound healing and soft tissue lesions, the nature of reparative processes, and functional capabilities, based on the analysis of the terms of restoration of limb function and working capacity.

RESULTS

As a result of the treatment, an acceleration of the dynamics of the wound process was observed in patients of the second group, which was manifested in a reduction in the healing time of fistulas (their cleansing, the appearance of granulations and the beginning of epithelialization) (Fig. 1). Radiologically, reparative changes and acceleration of bone regeneration were noted on the 22-23rd day after the injury (Fig. 2). Along with this, the formation of primary bone callus in patients of the control group, according to radiological dynamics, occurred on the 32-35th day after the injury.

The level of endotoxemia was assessed by the content in the blood of SMP, which are endogenous



Fig. 1. Patient K., Post-traumatic osteomyelitis of the bones of the left tibia. Scalped wound of the left tibia. Dynamics of the wound process
Picture taken by the authors

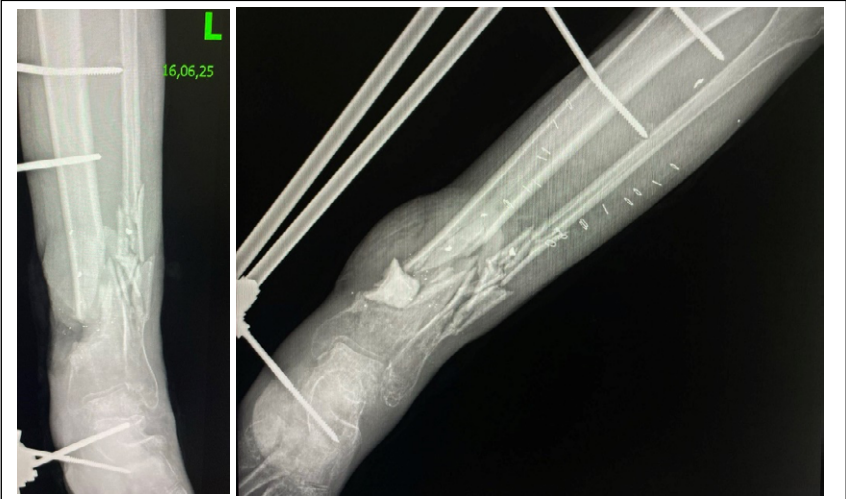


Fig. 2. Patient K., Post-traumatic osteomyelitis of the bones of the left tibia. Scalped wound of the left tibia. X-ray dynamics
Picture taken by the authors

compounds with an average molecular weight of 500 to 5000 d, the content of which increases with the increase in intoxication syndrome.

In patients with post-traumatic osteomyelitis, with increasing intoxication in the blood, the level of SMP sharply increased, mainly due to the pool, which is determined at a wavelength of 254 nm and

characterizes the toxic properties of the blood – up to 0.442 ± 0.05 in patients of the first (control) group and 0.445 ± 0.06 in the second (main) group; in healthy people – 0.333 ± 0.04 .

In patients with post-traumatic osteomyelitis, against the background of a decrease in the total number of lymphocytes (up to 21.6 ± 0.64 , in healthy

subjects – 44.4 ± 0.79), there was a sharp decrease in the number of Tx with a moderate decrease in Tc and a corresponding decrease in their ratio (Tx/Tc) to 1.02 ± 0.14 in patients of the first group and 1.04 ± 0.15 in the second (main) group (in healthy subjects 1.34 ± 0.12). The level of CIC in the blood increases to 32.46 ± 1.64 in patients of the first group and 34.76 ± 1.84 in the second (main) group; in healthy subjects 16.17 ± 0.53 .

After treatment, there is a tendency to normalize the ratio Th/Ts to 1.20 ± 0.12 in patients of the first group and to 1.24 ± 0.14 in the second (main) group. The level of CIC in the blood decreases – to 27.86 ± 2.02 in patients of the first group and 24.88 ± 1.94 – in the main group, but these indicators do not reach the indicators of healthy people.

DISCUSSION

Chronic or “prolonged traumatic” stress worsens the results of treatment of traumatic injuries, contributing to the development of inflammatory processes, worsening of wound healing and even increasing the likelihood of infectious complications. Chronic stress leads to an imbalance in the immune response, reduces the activity of cells responsible for protecting the body from infections and contributes to the chronicity of inflammatory processes [7]. In conditions of traumatic disease, this leads to a slowdown in healing and an increased risk of developing infectious-inflammatory complications, such as sepsis or osteomyelitis. Statistical data show that 30–40% of patients who experience severe injuries against the background of chronic stress have a higher risk of developing infectious-inflammatory complications, namely wound infections, impaired healing. Osteomyelitis is the most significant purulent-necrotic complication that affects reparative osteogenesis, which especially needs to be taken into account in traumatic disease. Regeneration

in this case should be considered as the most complex manifestation of life in extreme conditions. Since a bone fracture involves a violation of the integrity of the muscles, ligaments, skin and blood vessels, which in turn is a significant obstacle to regenerative mechanisms. That is why careful correction of regeneration processes in bone fractures against the background of a traumatic disease has important socio-economic significance, as it will significantly reduce the level of disability and loss of work capacity [5].

In the treatment of post-traumatic osteomyelitis of the long bones of the lower extremities, the use of regional infusion and the application of high-intensity laser radiation, along with monitoring and correction of chronic stress, allows stopping the progression of the purulent-necrotic process in the bone and soft tissues, allows achieving rapid sanitation of fistula passages and foci of purulent-necrotic process, accelerating the dynamics of the wound process and reparative processes in the bone, reducing the level of endotoxemia, activating immune defense, significantly reducing treatment times, reducing course doses of medications and achieving restoration of working capacity in the vast majority of patients. The effectiveness of the proposed treatment method has been proven, which allows avoiding disabling operations and restoring the function of the damaged limb more quickly.

CONCLUSIONS

The use of the method of prevention and treatment of osteomyelitic complications in long bone fractures, using high-intensity laser radiation against the background of regional intraarterial infusions, with correction of the state of «chronic stress», allows to accelerate the dynamics of the wound process and bone regeneration, shorten the treatment period, reduce the course doses of medications and achieve faster restoration of working capacity in most patients.

REFERENCES

1. Hofmann SR, Schnabel A, Rosen-Wolff A et al. Chronic nonbacterial osteomyelitis: pathophysiological concepts and current treatment strategies. *J. Rheumatol.* 2016;43:1956–64. doi: 10.3899/jrheum.160256. DOI
2. Schnabel A, Range U, Hahn G et al. Unexpectedly high incidences of chronic non-bacterial as compared to bacterial osteomyelitis in children. *Rheumatol. Int.* 2016;36:1737–45. doi: 10.1007/s00296-016-3572-6. DOI
3. Ferguson PJL. Autoinflammatory Bone Disorders. In: Petty L, Lindsley, Wedderburn, editor. *Textbook of Pediatric Rheumatology*. 7th Edition. Elsevier, Philadelphia. 2016, pp. 627–41.
4. Hofmann SR, Böttger F, Range U et al. Serum Interleukin-6 and CCL11/Eotaxin May Be Suitable Biomarkers for the Diagnosis of Chronic Nonbacterial Osteomyelitis. *Front Pediatr.* 2017;5:256. doi: 10.3389/fped.2017.00256. DOI
5. Schnabel A, Range U, Hahn G et al. Unexpectedly high incidences of chronic non-bacterial as compared to bacterial osteomyelitis in children. *Rheumatol. Int.* 2016;36:1737–1745. doi: 10.1007/s00296-016-3572-6. DOI
6. Hofmann SR, Kubasch AS, Ioannidis C et al. Altered expression of IL-10 family cytokines in monocytes from CRMO patients result in enhanced IL-1 β expression and release. *Clin. Immunol.* 2015;161:300–307. doi: 10.1016/j.clim.2015.09.013. DOI

7. Hedrich CM, Beresford MW, Dedeoglu F et al. Gathering expert consensus to inform a proposed trial in chronic nonbacterial osteomyelitis (CNO). *Clin Immunol.* 2023;251:109344. doi: 10.1016/j.clim.2023.109344. 
8. Hofmann SR, Kubasch AS, Range U et al. Serum biomarkers for the diagnosis and monitoring of chronic recurrent multifocal osteomyelitis (CRMO). *Rheumatol. Int.* 2016;36:769–79. doi: 10.1007/s00296-016-3466-7. 
9. Hofmann SR, Schnabel A, Rösen-Wolff A et al. Chronic nonbacterial osteomyelitis: Pathophysiological concepts and current treatment strategies. *Journal of Rheumatology.* 2016;43(11):1956–1964. doi: 10.3899/jrheum.160256. 
10. Hofmann C, Wurm M, Schwarz T et al. A standardized clinical and radiological follow-up of patients with chronic non-bacterial osteomyelitis treated with pamidronate. *Clin Exp Rheumatol.* 2014;32(4):604–9.
11. Chou PH, Lin HH, Su YP et al. Staged protocol for the treatment of chronic femoral shaft osteomyelitis with Ilizarov's technique followed by the use of intramedullary locked nail. *Journal of the Chinese Medical Association.* 2017;80(6):376–382. doi: 10.1016/j.jcma.2017.01.001. 
12. Fang CH, Tsai PI, Huang SW et al. Magnetic hyperthermia enhance the treatment efficacy of peri-implant osteomyelitis. *BMC Infectious Diseases.* 2017;17(516):1–12. doi: 10.1186/s12879-017-2621-4. 
13. McNally MA, Ferguson JY, Lau ACK et al. Single-stage treatment of chronic osteomyelitis with a new absorbable, gentamicin-loaded, calcium sulphate/hydroxyapatite biocomposite. *Bone Joint J.* 2016;98(9):1289–1296. doi: 10.1302/0301-620X.98B9.38057. 
14. Lu V, Zhang J, Zhou A, Krkovic M. Management of post-traumatic femoral defects with a monorail external fixator over an intramedullary nail. *Eur. J. Orthop. Surg. Traumatol.* 2022;32(6):9–1126. doi: 10.1007/s00590-021-03082-1. 
15. Chan JKK, Ferguson JY, Scarborough M et al. Management of Post-Traumatic Osteomyelitis in the Lower Limb: Current State of the Art. *Indian J. Plast. Surg.* 2019;52(1):62–72. doi: 10.1055/s-0039-1687920. 

The work was carried out in the framework of research work 0124U002167 «Monitoring of traumatic disease against the background of chronic stress».

CONFLICT OF INTEREST

The Authors declare no conflict of interest

CORRESPONDING AUTHOR

Stepan S. Filip

Uzhgorod National University

71 Minayska St, 88000 Uzhgorod, Ukraine

e-mail: filip.uz@i.ua

ORCID AND CONTRIBUTIONSHIP

Stepan S. Filip: 0000-0002-6549-3892   

Rudolf M. Slyvka: 0000-0002-0187-2711   

Yuriy P. Skripinets: 0000-0002-9741-4175  

Petro P. Popyrkanych: 0000-0002-4809-2640  

Andriy M. Bratasyuk: 0000-0003-4390-2357   

 – Work concept and design,  – Data collection and analysis,  – Responsibility for statistical analysis,  – Writing the article,  – Critical review,  – Final approval of the article

RECEIVED: 10.04.2025

ACCEPTED: 21.08.2025

