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ORIGINAL ARTICLE

Reconstruction of a short tibia stump after forced shortening with subsequent lengthening using the Ilizarov method

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ABSTRACT

Aim To demonstrate the feasibility of reconstructing a prosthetic stump in a complex defect using staged osteotomy and lengthening, as sufficient tibial stump length is required for successful prosthetic fitting and is not always achievable.

Methods In this article, we present a 25-year-old man diagnosed with a non-prosthetic short stump of the right tibia with extensive necrotized scars of the anterior and end surfaces, closely soldered to the bone sawdust, which underwent lengthening of the short stump of the tibia using the Ilizarov method.

Results The uniqueness of the procedure lies in tibial shortening combined with excision of pathologically altered tissues, stump formation, and subsequent osteotomy and lengthening of the tibial stump. Reconstruction lasted 105 days (5 days of fixation, 25 days of lengthening, and 75 days of fixation), resulting in the formation of a functional stump.

Conclusions A stump that provided functional prosthetics was created. We believe that the technique can be successfully used in young people even in the absence of soft tissue reserve of the stump.

Keywords: amputation, Ilizarov technique, myocutaneous flap, osteotomy, tibia

INTRODUCTION

Transtibial amputation is the most common type of amputation performed after trauma (1). According to American statistics (2), 41.9% of patients required revision after primary amputation. The majority of patients underwent revision of the residual stump, while in other cases, due to the short stump, revision surgery was performed on the thigh. However, regardless of the length, the advantage of the lower leg stump is the preservation of the knee joint (3). Transfemoral amputations lead to loss of the knee joint, muscle imbalance, reduced functionality, and a 65% increase in energy expenditure during movement (1,4).

Another possible solution for restoring limb function could be osteointegration surgery – the direct fixation of an artificial implant into living bone (5-7). Osteointegration is performed in people with transfemoral amputation (8-10). It improves mobility and the ability to move, reducing energy consumption compared to the traditional prosthesis with a sleeve. However, after transtibial amputation, osteointegration is rarely performed and is even considered contraindicated (11). Furthermore, revision surgery, reamputation, bone fractures, implant failure and loosening are often required after this procedure. The risk of infectious complications is 18-63% (12). A disadvantage of potential osteointegration is geometric problems with instability due to a curved femur. The main reason for the lack of interest in transtibial osteointegration is better objective mobility after conventional transtibial amputation (10).

The desire to preserve the knee joint in a short stump led to the idea of its lengthening. The literature describes cases of lengthening such stumps using the Ilizarov technique (13-18). At the same time, certain problems associated with premature consolidation of the posterior corticotomy site and soft tissues were identified (19).

Preliminary preparation of the skin and muscles was proposed using tissue expanders or myocutaneous flaps (13). Later, improved methods of lengthening, methods of creating synostosis without shortening the bone lever (20-23), and reconstructive interventions to expand the distal end of the stump (23) were developed, which allowed for positive functional results.

In the case presented in the article, the situation was complicated by the presence of extensive immobile scars, tightly fused with protruding bones.

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Unlike known methods, the goal in the presented case was to develop a new method for reconstructing the non-prosthetic remainder of the tibia, which includes removing the defect at the end of the remainder with shortening of the tibia and its lengthening using the Ilizarov method.

PATIENT AND METHODS

Patient and study design

A young man aged 25 previously healthy with no significant medical history or comorbidities sustained a mine-blast wound to his right lower limb with shattered soft tissue and bones of the shin. He underwent amputation of the upper third of his tibia. He previously underwent necrectomy, vacuum therapy, medication, dressings, and physiotherapy. The postoperative period was complicated by massive necrosis of the skin and adjacent tissues. After healing, a tibia stump was formed with extensive immobile scars, fused with protruding bone fragments (Figure1).

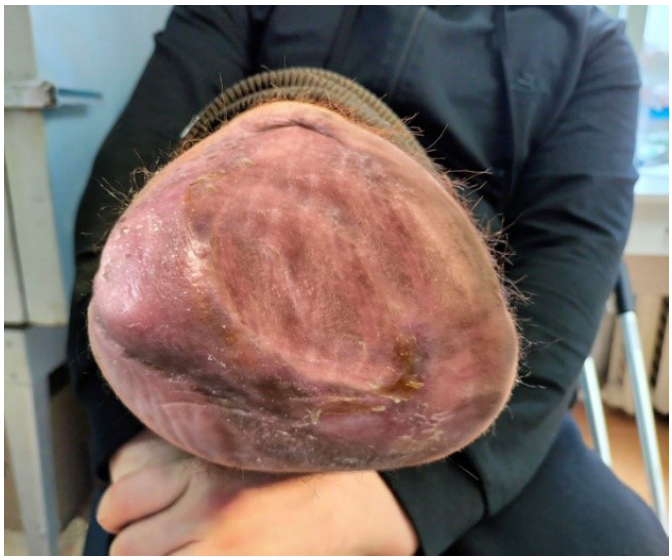

Figure 1.Tibial stump before surgery (Shevchuk V, 2021)

On the examination the prosthesis could not be loaded. Movement in the knee joint was full. The skin and muscles of the posterior and partially inner surface were preserved below the level of the bone amputation. A non-prosthetic short stump of the right tibia with extensive innervated scars of the anterior and end surfaces, closely soldered to the bone sawdust was found.
This study was approved by the Ethics Committee (Approval no: 24/2025, 30.06.2025). Written informed consent was obtained from the patient for the case details and images to be published.

Methods

After the flap incision with scar excision within healthy tissue was done, the bones were exposed. The preserved ends of the tibialis anterior, gastrocnemius, and long fibular muscles were isolated from the scars. The stumps of the tibia and fibula were truncated 6 cm proximal to the ends. Vessels were ligated, nerves were treated and shortened.
In the proximal metaphysis of the shortened tibia, 1.5 cm below the knee joint gap, perpendicular to the limb axis, without piercing the muscle tissue and taking into account the passage of the peroneal nerve, two cross pins were made, which were fixed in the ring of the Ilizarov apparatus (Federal State Budgetary Institution 'National Medical Research Centre of Traumatology and Orthopaedics named after Academician G.A. Ilizarov' of the Ministry of Health of the Russian Federation, Kurgan, Russia) (19). The *Pes anserinus* was separated from the tibia. The superficial medial collateral ligament was exposed. The distal part of the exposed ligament was separated from the bone. To protect the posterior neurovascular structures, a blunt retractor was inserted posteriorly to the medial collateral ligament and tibia. After isolating the medial border of the patellar tendon, it was cut subperiosteal from the tibial tuberosity. Under the intraoperative X-ray control with mobile C-arm imaging system control, two guide pins were placed 3.5 cm below the knee joint gap and parallel to it. Under the pins, a two-plane oblique-frontal and horizontal osteotomy of the tibia was performed directly under the pins using an oscillating saw so that the tuberosity remained on the proximal fragment (Figure2). Intraoperative control was performed using a mobile C-arm imaging system, and the mobility of the osteotomy site was checked. A self-tapping rod with a diameter of 3.5 mm in the sagittal plane and a spoke rod in the frontal plane were inserted through the distal tibia fragment perpendicular to the bone. The latter was fixed to the ring of the apparatus, which in turn was connected by threaded rods to the ring above.
Interfragmentary compression was performed in the osteotomy area. The antagonist muscles were stitched together. Active wound drainage was performed. The wound is sutured in layers.
The prosthesis quality index – The Locomotor Capabilities Index (LCI) as part of the Prosthetic Profile of the Amputee questionnaire was used to assess the patient's locomotor capabilities (24).

RESULTS

On the 5th day, distraction was started at 1 mm per day. Interfragmentary compression was continued for 4 days. X-ray control was performed every 15 days of fragment displacement. Distraction lasted for 75 days, fixation 75 days. The length of the regenerate obtained was 6 cm.
On the 15th day of distraction on control radiographs the height of the regenerate corresponded to the pace and rhythm of distraction. Cloud-like shadows of medium intensity were visible throughout the whole area. After 30 days, a normoplastic type regenerate was formed in the interfragmentary diastasis, evenly filling the diastasis (Figure2). After 60 days of distraction, the normoplastic regenerate was characterized by the presence of intense shadows of the proximal and distal sections and a medial zone of lucency. After 75 days of distraction, analogous results were observed. After 1 month of fixation, there was a fusion of the medial lucency zone. Homogeneous shadows of high intensity were determined. The cortical layer began to form on the posterior surface. After 2.5 months of fixation, there was fusion of bone trabeculae in the distal part of the regenerate. Well-formed cortical lamina was determined along the posterior and lateral edges. Scanning in the middle zone of the regenerate revealed vessels 0.28-32 cm in diameter with rheographicindices (RI) RI=3.61 and RI=1.4, indicating the maturity of the regenerate (Figure3). The Ilizarov apparatus was removed. The 6-centimetre regenerated bone had a homogeneous structure

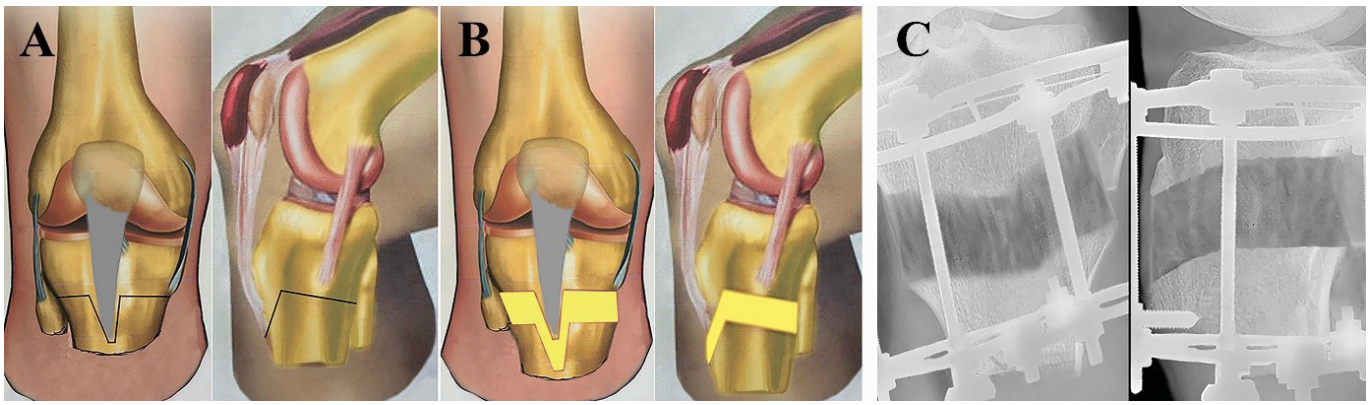

Figure 2. The osteotomy scheme and radiograph of distraction regenerate after 30 days after surgery. A) Schematic representation of the osteotomy site; B) Schematic representation of stump lengthening; C) X-ray image of the regenerated tibia 30 days after distraction (Shevchuk V, 2021)

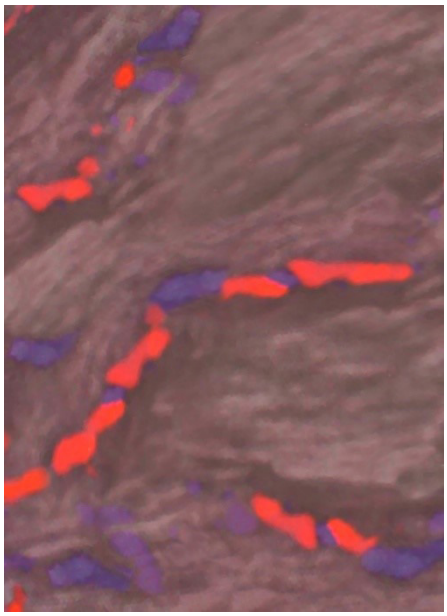

Figure 3. Scan of blood vessels in the regenerate 75 days after the surgery (Shevchuk V, 2021)

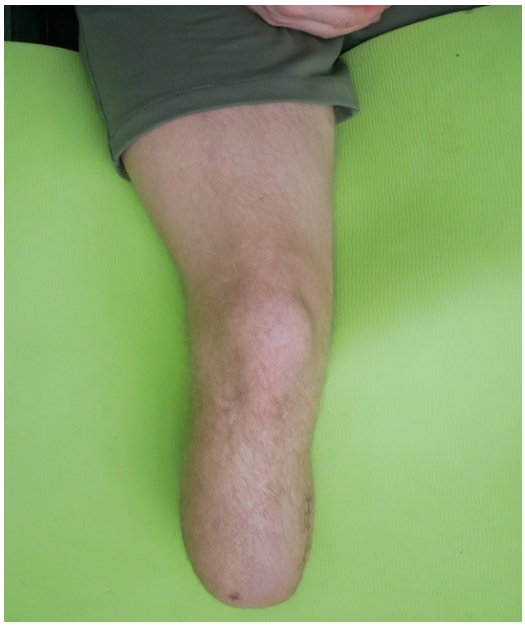

Figure 5. Moderately conical tibial stump one year after surgery (Shevchuk V, 2022)

of spongy bone tissue. In terms of density, it approached the adjacent areas of the mother bone (Figure 4). Nine and half months after the apparatus was removed, the density of the regenerate was slightly higher than that of the parent bone. The cortical diaphyseal layer was formed along the entire perimeter of the regenerate (Figure4). The shape of the stump was moderately conical (Figure5). After 3 years, the organotypic restructuring of the bone regenerate characteristic of this section was completed on radiographs in the lengthening zone (Figure4).

The prosthesis quality index – The Locomotor Capabilities Index (LCI) as part of the Prosthetic Profile of the Amputee questionnaire (24) after the operation was 55. The patient, who working as a mechanic in a garage used the prosthesis without additional means of support, and walked up to 12-13 km per day.

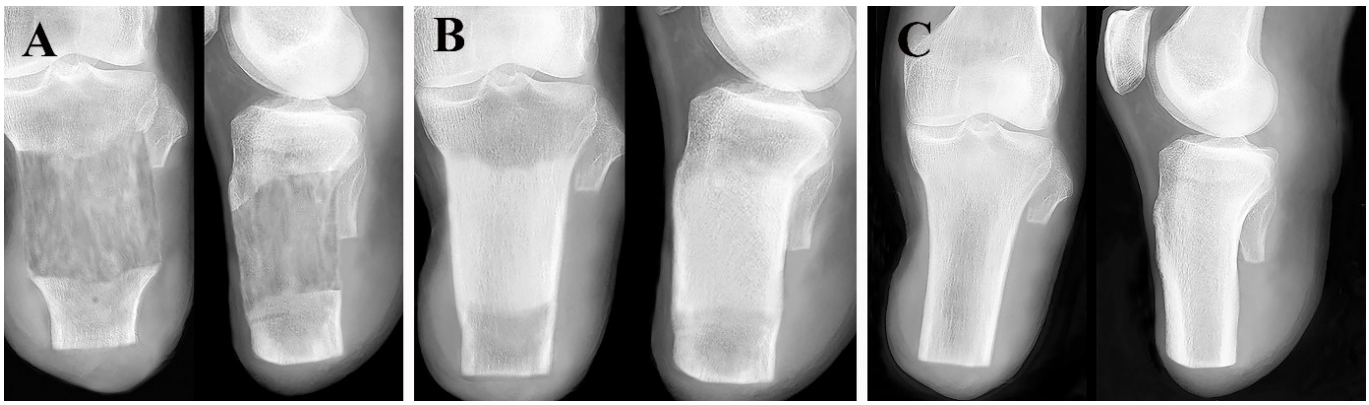

Figure 4. Radiographs presentation. A) distraction regeneration of the tibia after 75 days of lengthening (Shevchuk V, 2021); B) distraction regeneration of the tibia after 9.5 months; (Shevchuk V, 2021); C) tibial stump 3 years after surgery (Shevchuk V, 2023)

DISCUSSION

A transtibial amputation has definite advantages over a hip amputation in terms of greater functionality (3). However, prosthetics is sometimes complicated by a too short stump. There are isolated reports in the literature about the lengthening of the tibial stump (24). A prerequisite for stump lengthening is the creation of a soft tissue reserve, for which tissue expanders are used (13). In contrast to the known reports (13-17), the proposed technique involves removal of the defective end of the stump while preserving its length, which was achieved. Therefore, the first step of the operation was a high amputation of the tibia within healthy tissues with the formation of a soft tissue reserve with the expectation of subsequent lengthening. The second feature in our case was the performance of a two-plane osteotomy, which allowed us to obtain a fairly massive regenerate.

The presence of a dense capillary network in the epi-metaphyseal zone of the tibia creates favourable conditions for compensation of local microcirculatory disorders caused by osteotomy (25). Therefore, when compression was applied at the osteotomy site, an endosteal reparative reaction of the cancellous bone occurred, which made it possible to start distraction in 5 days (24).

As a result of traction forces application, conditions of tension with regenerate formation were created in the tissues. When the necessary length of the regenerate is reached, fixation conditions are created. During this period, the apparatus system was stabilized, performing only manipulations to ensure elastic tension of the fixation elements.

In the process of distraction, it may be necessary to prolong the action of tension forces. Technically, this is accomplished by further application of traction or compression forces, their sequential change, and recomposition of the apparatus.

The lengthening stage is divided into two periods: active lengthening, when compression and distraction are performed, and the fixation period, which is necessary for rebuilding the formed regenerate into mature bone tissue (24).

Possible complications of the **intervention** are most often associated with the insertion of the spokes (26,27). They can be divided into infectious (suppuration of soft tissues, purulent arthritis, dermatitis), non-infectious (reactive arthritis, vascular and nerve injury, joint contracture). When performing the intervention, complications may occur due to compression or distraction and improper application of the apparatus (impaired innervation, impaired trophism, joint contracture) (26,27). After removal of the apparatus, deformation of the regenerate or its fracture is possible (27). Observance of asepsis, uniform tension of the spokes, diagnosis and treatment of early and late inflammatory complications, timely removal and rewiring of the spokes will allow to stop the process. Knowledge of topographic anatomy and variants of location of the main neurovascular bundles excludes their damage. If a vessel is damaged, the spoke should be removed and a new one should be inserted next to it (26,27). Bleeding is stopped by pressing the puncture site with a tampon. If the peroneal nerve is damaged, the spoke must be removed (26,27).

According to Latimer (14), some patients had a significant loss of length of the regenerate after lengthening. The authors attribute these findings to early functional loading. In our opinion, to prevent shortening caused by compression during early loading, it is necessary to overstretch the regenerate by 1–2 cm in advance, which apparently was not considered by these and other researchers (2), as no reference to this approach is provided. In addition, after the end of distraction, the distance between the rings should be increased 1 mm every 5-7 days (13,14). None of the available reports (13,18) provided information on the exposure of the anterior medial ligament, severing its distal part from the bone, or sub periosteal severing of the medial part of the patellar tendon from the tibial tuberosity, which could also affect the shortening of the regenerate.

Our clinical experience shows that in case of sharply expressed osteoporosis with the formation of the cortical layer due to the possibility of crumpling or secondary resorption of the porous bone area under the influence of functional overload, it is necessary to provide the conditions of the most gentle mode of increasing the functional load.

After removing the appliance, conditions of regenerate deformation or fracture may occur. Therefore, the device can be removed when the density of the regenerate on the radiograph approaches the density of the surrounding bone.

These possible errors and complications arise due to incorrect tactics and techniques of using the Ilizarov apparatus and should not be a barrier when performing reconstructive interventions on the bone stump (27). Such interventions can improve the quality of life of patients, and knowledge of the causes and conditions of possible errors and complications opens real ways to their prevention (27).

The most important limitations of the study are: a single case which does not allow giving a number of theoretical and biological explanations; residual limb after amputation due to obliterating diseases of the peripheral vessels of the joints; festering inflammation of the skin; insufficient use of the apparatus of external fixation; a long period of time for obtaining the regenerate and its rebuilding.

On the example of the presented clinical observation, the authors demonstrated the saving tactics, real possibility, technical details and quite satisfactory results of a non-standard variant of surgical treatment of a patient with malformed stump of the tibia.

Stable fixation, fractional distraction, and maintenance of elastic tension of the fixation elements contribute to the formation of a newly formed bone area and high-quality prosthetics. Similar techniques can be used in young people after amputation with removal of extensive scars fused with protruding bone and end-stage osteomyelitis. To obtain optimal results, the technique can be adapted to individual cases.

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TRANSPARENCY DECLARATION

Conflicts of interest: None to declare.

REFERENCES

1. Felder JM 3rd, Skladman R. Translating technique into outcomes in amputation surgeries. Mo Med 2021;118(2):141–6.
2. Gwinn DE, Keeling J, Froehner JW, McGuigan FX, Andersen R. Perioperative differences between bone bridging and non-bone bridging transtibial amputations for wartime lower extremity trauma. Foot Ankle Int 2008;29(8):787–93.
3. Baumgartner R, Botta P. Amputation und Prothesenversorgung der unteren Extremilat. Stuttgart/Germany: Ferdinand EnkeVerlag, 1995:486.
4. Pinzur MS. Outcomes-oriented amputation surgery. PlastReconstrSurg 2011;127 Suppl 1:241–7.
5. Marano AA, Modiri O, Rozbruch SR, Otterburn DM. Soft tissue contouring at the time of osseointegrated implant reconstruction for lower extremity amputation. Ann PlastSurg 2020;85(S1 Suppl 1):33–6.
6. Brånemark R, Berlin O, Hagberg K, Bergh P, Gunterberg B, Rydevik B. A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J 2014;96-B(1):106–13.
7. Hagberg K, Ghassemi Jahani SA, Kulbacka-Ortiz K, Thomsen P, Malchau H, Reinholdt C. A 15-year follow-up of transfemoral amputees with bone-anchored transcutaneous prostheses. Bone Joint J 2020;102-B(1):55–63.
8. Gerzina C, Potter E, Haleem AM, Dabash S. The future of the amputees with osseointegration: A systematic review of literature. J ClinOrthop Trauma 2020;11(Suppl 1):142–8.
9. Brånemark RP, Hagberg K, Kulbacka-Ortiz K, Berlin Ö, Rydevik B. Osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: a prospective five-year follow-up of patient-reported outcomes and complications. J Am AcadOrthopSurg 2019;27(16):743–51.
10. Akhtar MA, Hoellwarth JS, Al-Jawazneh S, Lu W, Roberts C, Al Muderis M. Transtibial osseointegration for patients with peripheral vascular disease: A case series of 6 patients with minimum 3-year follow-up. JB JS Open Access 2021;6(2):e20.00113.
11. Van de Meent H, Hopman MT, Frölke JP. Walking ability and quality of life in subjects with transfemoral amputation: a comparison of osseointegration with socket prostheses. Arch Phys Med Rehabil 2013;94(11):2174–8.
12. Gerzina C, Potter E, Haleem AM, Dabash S. The future of the amputees with osseointegration: A systematic review of literature. J ClinOrthopTrauma 2020;11(Suppl 1):142–8.
13. Eldridge JC, Armstrong PF, KrajbichJI. Amputation stump lengthening with the Ilizarov technique. A case report. ClinOrthopRelat Res1990;(256):76-9.
14. Latimer HA, Dahners LE, Bynum DK. Lengthening of below-the-knee amputation stumps using the Ilizarov technique. J Orthop Trauma1990;4(4):411-4.
15. Schneider PS, Brinker MR. Belowknee amputation stump lengthening. In: Rozbruch SR, Hamdy RC, editors. Limb Lengthening and Reconstruction Surgery Case Atlas. Switzerland: Springer International Publishing, 2015: 385-9.
16. Mertens P, Lammens J. Short amputation stump lengthening with the Ilizarov method: risks versus benefits. ActaOrthopBelg2001;67(3):274-8.
17. Park HW, Jahng JS, Hahn SB, Shin DE. Lengthening of an amputation stump by the Ilizarov technique. A case report. IntOrthop1997;21(4):274-6.
18. Toon DH, Khan SA, Wong KHY. Lengthening of a below knee amputation stump with Ilizarov technique in a patient with a mangled leg. Chin J Traumatol2019;22(6):364-7.
19. Ilizarov GA. Clinical application of the tension-stress effect for limb lengthening. ClinOrthopRelat Res 1990;(250):8-26.
20. Shevchuk VI, Bezsmertnyi Y, Bezsmertnyi OY, Branitsky OY. Modification of Ertl operation for short stump. Orthop Res Rev 2024;16:171–8.
21. Bezsmertnyi YO, Shevchuk VI, Bezsmertnyi OY, Branitsky OY, Bondarenko DV. Bone bridge transtibial amputation by an innovative technique. JAAOS Glob Res Rev 2024;8:e24.00063.
22. Shevchuk VI, Bezsmertnyi YO, Bezsmertnyi OY, Branitsky OY. Ertl surgery on the short fibula stump. MedGlas (Zenica) 2024;21(2):379-84.
23. Bezsmertnyi YO, Shevchuk VI, Branitsky OY, Bezsmertnyi OY. Reconstruction of a short tibial stump with a long fibula using the Ilizarov technique: A Case study. OrthopResRev 2024;16:243–9.
24. Gauthier-Gagnon C, Grisé MC. Tools to measure outcome of people with a lower limb amputation: update on the PPA and LCI. J ProsthetOrthot 2006;18(6):61–7.
25. LopezCurto JA, Bassingthwaighte JB, Kelly PJ. Anatomy of the microvasculature of the tibial diaphysis of the adult dog. J BoneJointSurgAm 1980;62(8):1362–9.
26. Malkova TA, BorzunovDY. International recognition of the Ilizarov bone reconstruction techniques: Current practice and research (dedicated to 100th birthday of G. A. Ilizarov).World J Orthop 2021;12(8):515–33.
27. Feng D, Zhang Y, Jia H, Xu G,Wu W,Yang F,etal. Complications analysis of Ilizarov bone transport technique in the treatment of tibial bone defects – a retrospective analysis of 199 cases. BMC MusculoskeletDisord 2023;24(1):864.