Original Articles

DOI 10.18019/1028-4427-2018-24-2-126-133

Organization of specialized surgical help to patients with peri- and intraarticular lover limb's fractures

Yu.V. Antoniadi

Ural State Medical University, Ekaterinburg, Russian Federation

The aim of this work is to develop a system of surgical treatment of intra- and periarticular fractures of lower limb bones for improving the results and reducing the number of postoperative complications. **Material and methods** Short- and long term results of surgical treatment of 390 patients with peri- and intraarticular lower limb fractures treated at a trauma department 1 of hospital # 24 in the period between 2010 and 2014 were analyzed according to a similar schedule of requirements to recovery of anatomic and functional parameters of the hip, knee and ankle joint. There were 198 men (50.8 %) and 192 women (49.2 %). Radiological, clinical and statistical research methods were used. Statistical methods included estimation of significance of differences for parametric and non-parametric criteria, assessment of the relationship signs on the Pearson's coefficient of linear correlation. To study the results of hip treatment the Harris Hip Score (H.W. Harris, 1969) was used, in the region of the knee – P.S. Rasmussen scale (1973), and in the ankle – of E. Mazur (2006) which include subjective and objective criteria. **Results** Good functional outcomes were obtained in 87.1 % of femoral neck fractures, in extra-articular fractures of the proximal femur – in 76.2 %, in intra-articular fractures of the distal femur – in 75.0 %, intra-articular fractures of the proximal tibia – in 78.3 %, intra-articular fractures of the distal tibia in 96.6 % of cases. **Conclusion** Implementation in the clinical practice of the system of surgical treatment of peri- and intraarticular fractures, including improved diagnostics, practical orientation of injury systematization, algorithms for clinical diagnostic search, consecutive use of external and internal osteosynthesis, rational technique of joint arthroplasty, new technologies of osteosynthesis with a differentiated choice of metal fixators, a modified proximal femoral metal fixator, approaches to joints, methods for bone defect plasty; all these factors combined with the method of perioperative management of patients and early active rehabilitation achieved the prevalence of excellent and good anatomical and functional results for each studied location of injurie in main subgroups in comparison with the control ones.

Keywords: lower limbs, intra-articular fracture, periarticular fracture, osteosynthesis, surgical treatment

INTRODUCTION

IIn the recent decades, the number of patients with intra- and periarticular fractures of the lower limb bones has increased and amounts to 40 to 50 % of all skeleton injuries, which is due to the growth of road and industrial accidents. Treatment of this type of fracture is technically a difficult task, which is due to the initial complexity of the biomechanics of the lower limb, kinematics of the hip, knee and ankle joints, anatomical and functional features of their structure, and the combination of multifragmentation with impression and defects of the subchondal bone tissue. Inaccuracies in the reduction of the articular surface and periarticular parts of the femur and tibia, inadequate choice of surgical access and metal fixator, rejection of impression defect plasty lead to the development of severe posttraumatic osteoarthritis accompanied by deformities and joint contractures in 5.8-28 % of cases; the disability rate reaches 15 % [1, 2].

Modern approaches to the treatment of peri- and intraarticular injuries consist in active surgical tactics using the methods of arthroplasty and osteosynthesis (external transosseous one with external fixation apparatuses (EFA) and internal one with metal implants). Any of the osteosynthesis methods should ensure the stability of bone fragments fixation and the functionality of the affected joint. The reduction of the articular surface and the management of the impression defect with the EFA are traditionally performed in a closed manner, which is not always effective. In addition, delayed consolidation of the intraarticular fracture requires prolonged fixation in the apparatus, which is accompanied by discomfort and the need for constant monitoring of bone fragments compression, skin condition, integrity and tension of the wires [3-7].

The method of closed intramedullary osteosynthesis (CIMO) using cephalomedullar

Antoniadi Yu.V. Organization of specialized surgical assistance to patients with peri- and intraarticular lower limb fractures. *Genij Ortopedii*. 2018. T. 24. No 2. pp.126-133. DOI 10.18019/1028-4427-2018-24-2-126-133, (In Russian)

structures has been successfully applied for treatment of periarticular fractures of the proximal femur. However, it is quite difficult to achieve an adequate stability of the metal fixator, especially in elderly patients with porous bone tissue. For osteosynthesis of peri- and intraarticular fractures of other locations, CIMO has been used by single surgeons. The issue of adequate management of the impression defect remains open.

Plating is most successful with intra- and periarticular fractures in the knee and ankle joint area. However, the use of modern metal plates does not always provide sufficient stability; even after adequate primary reduction, a secondary displacement of the fragments and joint deformity happen in 30 % of cases after the operated limb starts to be loaded on. It can be explained by a decrease in the strength characteristics of bone tissue as a result of trauma and age-related changes. Adequate surgical access improves visualization of intraarticular lesions, but the question of choosing the optimal approach to the proximal and distal parts of the tibia remains open. The problem of compensation of epimetaphyseal defects in the acute period of trauma has also not been solved [8-12].

Thus, based on the current state of the problem, it can be concluded that there is no single systematic approach to the treatment of severe peri- and intraarticular fractures of the lower limbs, based on the mechanogenesis of trauma, damage morphology, and aimed at restoring anatomical and functional parameters, kinematics of the hip, knee and ankle joints. Questions of systematization of joint trauma remain open. Despite the existing variety of methods for surgical treatment of peri- and intraarticular fractures of the bones of the lower extremity, the optimal tactics for perioperative management have not been determined; measures to prevent the instability of hip joint implants and migration of metal fixators in proximal femur fractures in elderly patients have not been developed. The existing surgical approaches to the proximal and distal tibia do not provide adequate visualization of the damage zone, which makes it difficult to perform reduction of the joint surface and osteosynthesis. Discussion continues about the plasty of impression defects and the choice of osteoplastic material. Particular attention should be paid to the problem of postoperative rehabilitation, the main directions of which should be the full recovery of movements in the injured joint and the prevention of posttraumatic osteoarthritis.

The **purpose** of this work was the development of a system for surgical treatment of peri- and intraarticular fractures of the bones of the lower extremities, the introduction of which into practical health care would improve the results and reduce the number of postoperative complications.

MATERIAL AND METHODS

In this study, five zones of peri- and intraarticular fractures of the lower extremity bones, and namely, the femoral neck (FN), proximal femur (PF), distal femur (DF), proximal tibia (PT), distal tibia (DT) were defined significant for the function of the three major support joints – the hip, knee and ankle. Accordingly, five clinical groups with these affected areas were formed; each was divided into two subgroups, based on the type of treatment technology used.

To maintain the statistical validity of the study, the homogeneity of the groups was assessed by the following indicators: age, type of fracture, and gender. The subgroups are pairwise estimated by a nonparametric method using the Mann-Whitney test and the evaluation of the conjugacy criteria for qualitative characteristics (gender and type of AO / ASIF fracture) using the chi-square statistic at significance level $p < 0.05$. For the parameters studied, the value of $p > 0.05$ was obtained, which made it possible to reject the hypothesis of the existence of an interrelation and to treat the groups as statistically homogeneous [3]. The number of patients by groups, the control one and main subgroups is presented in Table 1.

TThe main subgroup was composed of patients (n = 137) who were treated in the period from 2013 to 2014 with new and improved technologies developed during the research. The control subgroup (n = 162) included patients treated with traditional methods of osteosynthesis in the period from 2010 to 2012. A comparative analysis of the effectiveness of treatment in the main and control subgroups was conducted in the short term (3 and 6 months) and mid-term follow-ups (12, 24 and 36 months).

Table 1

Number of patients according to groups, control groups and main subgroups

Fracture location	Number / %	Number of middle-term results studied / % from the total	Number of patients in subgroups*	
			control	main
Femoral neck fractures	157 / 100	119 / 75.8	65	54
Extraarticular fractures of the proximal femur	108 / 100	87 / 80.6	45	42
Intraarticular fractures of the distal femur	23 / 100	18 / 78.2	10	8
Intraarticular fractures of the proximal tibia	51 / 100	38 / 74.5	20	18
Fractures of the distal tibia	51 / 100	37 / 72.5	22	15
Total	390 / 100	299 / 76.7	162 / 54.2	137 / 45.8

* – compared subgroups are representative inbetween, $p < 0.05$

According to the Universal AO / ASIF Classification of fractures (1996), all femoral neck fractures (n = 157) were of type B (type B1 – 4 patients (2.2 %), type B2 – 23 patients (12.4 %), B3 type – 130 patients (70.3 %)). Periarticular PF fractures (n = 108) according to AO/ASIF classification were as follows: type A1 fractures – 51 (47.2 %), fractures of A3 type – 17 (15.7 %); unstable A2 fractures accounted for more than one third of cases – 40 (37.1 %). The intraarticular fractures of the DF (23) according to AO/ASIF (1996) were systematized as follows: type B2 – 9 cases (39.2 %), type C1 – 7 (30.4 %), C2 – 5 (21.7 %), C3 – 2 (8.7 %); the fractures of type B2 and C1 prevailed (39.2 % and 30.4 %, respectively). Intraarticular fractures of type C3 (8.7 %) were less common.

Intraarticular PT fractures (n = 51), according to the J. Schatzker classification (1979), were distributed as follows: type I – wedge fracture of the lateral plateau – 8 (15.7 %); II type – wedge fracture of the lateral plateau combined with impression of the joint surface – 12 (23.5 %); III type – isolated impression of the segment of the lateral plateau – 13 (25.5 %); IV type – fractures of the medial part of the tibial plateau – 3 (5.9 %); V type – fractures of both condyles – 11 (21.6 %); VI type – injury to the articular surface of the plateau combined with a fracture at the border of the tibial metaphysis and shaft – 4 (7.8 %). Intraarticular DT fractures (n = 51) were systematized according to the classification of Ruedi-Allgower (1969): type I – fractures without displacement – 11 (21.6 %), type II – fractures with displacement – 16 (31.4 %), type III – fractures with impression damage to the joint surface – 24 (47 %). Type III fractures were detected in the youngest group of patients (mean age 45.1 ± 1.7 years) that suffered high-energy trauma.

Treatment of patients of the first group with FN fractures was arthroplasty. The system of BiContact® Aesculap Orthopaedics with cement fixation was implanted in all 157 cases. The main technical elements of the intervention were conventional for cemented joint replacement. While this research was on the way, the technology of arthroplasty was improved, beginning with the preoperative planning stage. Due to the modularity of the head, the amount of offset was optimized to equal values with the contralateral joint. No electric power tools were used by treatment of the acetabulum; after primary treatment with a milling cutter in the porous bottom of the acetabulum, spongy bone tissue from the resected femoral head was impacted as a sector autologous graft that assisted in avoiding protrusion of the pelvic component and loss of offset.

The second group of patients with periarticular fractures of the proximal femur was treated by closed osteosynthesis in the supine position of the patient; fracture reduction was performed by skeletal traction or in the reduction device of the operating orthopedic table. The following types of fixators for osteosynthesis were used: (1) dynamic femoral screw – 12 (11.1 %); dynamic condylar screw – 3 (2.7 %); standard proximal femoral fixator (SPFF) – 45 (41.7 %); modified proximal femoral fixator (MPBF) with an oval hole for distal locking – 26 (24.1 %), proximal femoral fixator (PFF) with a modified neck screw – 16 (14.8 %); reconstructive femur nail – 6 (5,6 %) cases. Two modifications of the standard proximal femoral fixator (PFF) were developed and introduced into clinical practice: (1) transformation of the distal round hole for locking screws into an oval (Patent No. 2473317 RF) [13] and (2) the transformation of the neck screw into a cylinder with a metric thread on the external surface, and a dead hole at the lateral end, segmental grooves on the medial part along the external diameter with equally spaced through holes on the protrusions of the grooves (Patent RF № 154108) [14]. The modulus of stiffness of the modified neck screw is close to the

bone rigidity modulus. Modifications of the standard PFF were approved for clinical use by the local ethics committee of the Federal State Educational Institution of Higher Education Ural State Medical University of the Ministry of Health of the Russian Federation (protocol No. 6 of June 24, 2016).

The traditional method of open reduction and internal fixation with bone metal structures (11 cases – 48 %) and the combined method proposed by us (12 cases – 52 %) were used to treat patients of the third group with DF fractures. For femur osteosynthesis, two types of fixators were used: (1) a supportive condyle plate with limited contact (n = 8, 34.8 %) and (2) a distal supporting condyle plate with angular stability (n = 15, 65.2 %). The combined method of treatment proposed as a new technology consisted in carrying out an open reduction of the fracture and osteosynthesis in the conditions of the hinge-distraction external fixation apparatus.

Treatment of the fourth group with intraarticular PT fractures was aimed at accurate reduction of the fracture in the area of the articular surface to provide conditions for the formation of hyaline cartilage to restitute the defects of the subchondral bone. For osteosynthesis, supporting condyle plates (72.5 % – 37 patients), T- and L-shaped support plates, plates with angular stability (27.5 % – 14 patients) (L-shaped LCP plate, ChM) were used. Fixation with the plates was combined with subchondral fixation using two or five 6.5 mm screws for spongy bone. The distraction module of the external fixation device was installed in the patients of the main subgroup intraoperatively that, under conditions of improved visualization, allowed a complex audit of the joint to perform final functional stable fixation of the fracture with the help of metal plating. The developed L-shaped lateral and medial approaches were used (Patent No. 2525211 RF) [15].

In patients of the fifth group with DT fractures, methods of open reduction, internal fixation of the tibia and fibula (if injured) with bone autologous plasty in cases of impression defects and the method of closed transosseous osteosynthesis with external fixation apparatus were used. Open osteosynthesis with a plate (plates) for type I fracture according to Ruedi-Allgower (1969) was performed in 11 (21.6 %), for type II in 16 (31.4 %), type III in 18 (35.3 %) cases. Osteosynthesis using AEF was used in 6 patients (11.7 %) with type III injury. With the purpose of early elimination of rotational and axial displacements of fragments of the distal tibia and fibula and optimization of this group of patients from the moment of admission to the hospital, new methods of combined osteosynthesis have been developed and introduced into practice (Patent No. 2564080 RF) [16]. A new approach to the distal epimetaphysis of the tibia in the conditions of the AEF distraction module was also developed (Patent No. 2623298 RF) [17].

The Harris scale (Harris W.H., 1969) was used to study the results of treatment of fractures in the hip area, P.S. Rasmussen system (1973) in the knee joint area, E. Mazur (2006)in the ankle joint, including subjective and objective criteria. To determine the reference X-ray parameters, X-ray images were digitized and processed with the "WeasisMedicalViewer" version 2.17.1. To assess the accuracy of reduction and its retention in the short- and long-term period after osteosynthesis, the difference in anatomical and biomechanical parameters with the contralateral side was studied, the restoration of such X-ray parameters as the neck-to-shaft angle (NSA) and hip offset (HF), distal epiphyseal-diaphyseal angle of the femur (DEDAF), femoro-tibial (FTA), plateau-diaphyseal (PDA) and distal epiphyseal-diaphyseal (DEDAT) angles of the tibia. Statistical processing of data was carried out using the SPSS data analysis package.

RESULTS

In the first group at 36 months after the operation, the rate of excellent and good results of treatment in the main subgroup (87.1 %) prevailed over the control group (78.4 %) 1.1 times, $p < 0.05$. Fair results in the control subgroup (18.5 %) exceeded that of the main subgroup (12.9 %). Poor outcomes were in 2 cases in the control subgroup (aseptic instability of the cup). The decrease in the effectiveness in the control subgroup is due to the residual lameness due to the difference in the biomechanical parameters of the implant and the contralateral hip joint, and also because of the protrusion position of the pelvic component and the development of its instability within 36 months after the operation.

In the second group, the total of excellent and good results (76.2 %) in the main subgroup exceeded the similar parameters of the control subgroup (46.7 %) by 1.6 times $p < 0.05$. Poor results of treatment in the patients of the control subgroup were 4.6 times more frequent than in patients of the main group (11.1 % and 2.4 %, respectively), $p < 0.05$. The result was considered poor in one patient of the main

subgroup due to migration of PFF with a modified neck screw. In patients of the control subgroup, five cases of delayed consolidation due to migration of the standard PFF were considered as poor outcomes.

In the third group at 36 months after the operation, the rate of excellent and good results in the main subgroup (62.5 %) prevailed over the control group (30.0 %), $p < 0.05$. Poor results were revealed only in the control subgroup. At long-term observation period, complications occurred in 2 (11.1 %) patients of the control subgroup. After 12 months, one patient with C2 type of fracture had a secondary displacement of the femoral condyles fragments by more than 10 mm which led to fracture malunion and posttraumatic development of knee osteoarthrosis; and in one patient with C2 type of fracture, distal screws migrated and the plate fractured at 24 months after the surgery, which required repeated surgical intervention. The patients of the main subgroup had no significant complications at the mid-term follow-up.

In the fourth group, 36.8 months after the operation, excellent and good results of treatment were 77.8 % in the main subgroup and 30.0 % in the control subgroup ($p < 0.05$). Fair results in the control subgroup were almost 3 times higher than in the main subgroup (60.0 % and 22.2 %, respectively). Poor outcomes were revealed only in the control subgroup.

In the fifth group, 36 months after surgery, the results were similar: excellent and good treatment results in the main subgroup (93.3 %) prevailed over the control group (68.1 %) 1.4 times ($p < 0.05$). Fair results in the control subgroup were 3.4 times more frequent than in the main one (22.7 % and 6.7 %, respectively). Poor results were observed only in the control subgroup.

Thus, our study proved statistically the advantages of using the developed system of surgical treatment for peri- and intraarticular fractures of the bones of lower extremities, including new methods of osteosynthesis as compared with standard technologies used in the clinic until 2012. In the long-term follow-up period, the rate of excellent and good treatment outcomes prevailed in the main subgroups of all five study groups, which is graphically shown in the form of bar charts (**Fig. 1**).

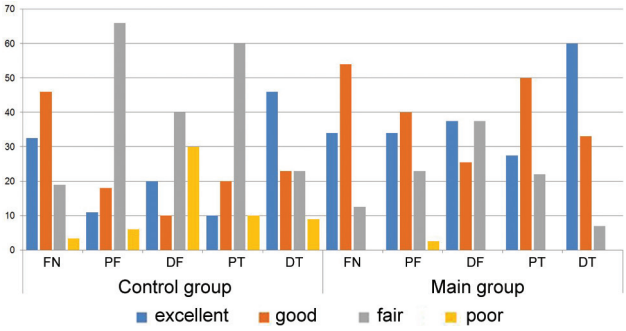

Fig. 1 Diagram of the comparative analysis of the effectiveness of treatment in the main and control subgroups of five groups of patients with fractures of the femoral neck (FN), proximal femur (PF), distal femur (DF), proximal tibia (PT), distal tibia (DT) at mid-term follow-up (36 months)

DISCUSSION

Traditionally, the method of transosseous osteosynthesis with AEF involves closed reduction of fractures, which does not always allow adequate restoration of the congruence of articular surfaces and impression defects. In addition, delayed consolidation of the intraarticular fracture requires a long fixation time, which is accompanied by discomfort and the need for constant monitoring of bone fragments compression, skin condition, integrity and wire tensioning.

The CIMO method for peri- and intraarticular fractures is used by single surgeons [18]. The main difficulties by closed nailing of fractures of the proximal and distal parts of the tibia are the elimination of valgus and antecurvatum deformities; adequate management of impression defect also remains open. Repeated operations are required in 28 % of cases after performing CIMO for intra-articular fractures [19].

The most successful with intra- and periarticular fractures in the knee and ankle joint area is bone osteosynthesis using plates. However, modern plates do not always provide sufficient stability, even after adequate primary reduction. Secondary displacement of fragments and joint deformities happen in 30 % of cases after the start of loading the operated limb, which can be explained by a decrease in the strength characteristics of bone tissue as a result of trauma and age changes [20]. Improved visualization of intraarticular lesions allows adequate surgical access, but the question of choosing the optimal approach to the proximal and distal parts of the tibia remains open. The problem of compensation of epimetaphyseal defects in the acute period of trauma is also not solved [21].

The work on the problem of intraarticular trauma repair resulted in the formulation of the basic principles of surgical treatment of peri- and intraarticular fractures of the lower limb bones:

• Ensuring decompression of the affected joint in few hours after injury;

• Total arthroplasty for hip fractures in elderly patients, regardless of the time relapsed after the injury, bone tissue

and morphology of the fracture (stable or unstable), with the selection of the implant components in accordance with the parameters of the contralateral hip joint;

• Implementation of closed osteosynthesis with a modified gamma-rod with the possibility of dynamization in extraarticular fractures of the proximal femur: with the integrity of the medial support complex (Adams arch, small trochanter) – short femoral stem (220 mm), otherwise – a long femoral stem (longer than 220 mm);

• In intraarticular fractures in the knee and ankle joint area – primary reduction and early decompression of articular surfaces in the distraction module of the Ilizarov apparatus;

• Open osteosynthesis of intraarticular fractures of the knee and ankle joint area by supporting plates (after normalization of soft tissue condition) with the obligatory restoration of the integrity of the articular surface, the main angular and axial anatomical and biomechanical parameters of the limb;

• Filling the subchondral impression bone defect with autologous bone graft or synthetic biocomposite if an impression defect is 5 mm or more;

• Intraoperative recovery of the full range of movements in the joint, postoperative cast immobilization in conditions of stable osteosynthesis is not required;

• Postoperative decompression of the joints (soft-tissue traction in the functional splint, walking with additional support means without load on the operated limb);

• Rehabilitation treatment and correction of structural and metabolic insufficiency of damaged articular cartilage and subchondral bone (hyaluronic acid preparations and other chondroprotectors) in the long-term postoperative period.

In order to avoid errors in clinical assistance for patients with severe intraarticular injury, we developed and implemented algorithms of the clinical diagnostic examination, including obligatory diagnostic and therapeutic measures for the groups of intraarticular injuries according to the order of rendering medical aid to the population with the trauma and orthopedic disorders (Order of the Ministry of Health of the Russian Federation of November 12, 2012 No. 901n). According to the algorithms, after the provision of emergency intraarticular care, the first stage of complex surgical treatment is carried out in the admission unit and consists in primary reduction and stabilization of fractures with the AEF distraction modules. Once admitted, the injured are pre-examined and the morphology of the fracture is clarified with the help of CT examination in AEF conditions. After the normalization of the soft tissues, depending on the location and type of fracture, the optimal surgical approach and osteosynthesis method are chosen, internal osteosynthesis and the metal fixator. Next, with application of new technological methods, the second stage of surgical treatment is performed or final osteosynthesis. Further on, the patients are followed up outpatiently, continue rehabilitation up to final recovery.

Anatomical and functional approach, principles of treatment, advanced diagnostic measures, practically directed systematization of damages, algorithms for clinical diagnosis that determine the tactics of managing the injured at the stage of admission and at a clinical unit, consecutive use of transosseous and internal osteosynthesis, rationalization of arthroplasty techniques, new technologies of osteosynthesis with a differentiated choice of a metal fixator, a proximal femoral metal fixator with a modified neck screw, access to the joints, methods for defect plasty with bone tissue, perioperative management of patients and early active rehabilitation in the complex represent a scientifically based system of surgical treatment of peri- and intraarticular fractures of the lower limb bones. Standardization of necessary diagnostic and treatment procedures provides optimization of assistance to the most severe group of injured with joint trauma, prevents diagnostic errors at the stage of hospitalization, thereby, improves the quality of the medical process as a whole.

Case report Patient R., 55 years old, fell in the street on the knee joint area. He was hospitalized in trauma department No. 1 of the Moscow State Clinical Hospital No. 24 with the diagnosis of impression fracture of the condyle of the right tibia, type B2.3 according to AO / ASIF classification, type II according to J. Schatzker (1979) (**Fig. 2**).

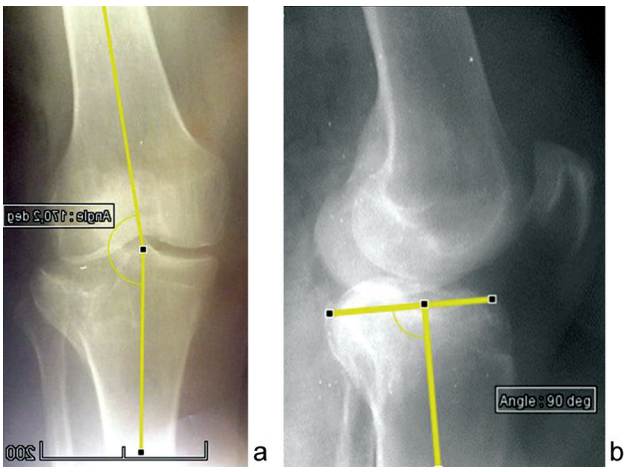

Fig. 2 Radiographs of the right knee joint of patient R., 55 years old, in AP (a) and lateral (b) projections upon admission: an impression fracture of the lateral condyle of the tibia of B2.3 type according to AO / ASIF classification, type II according to the classification J. Schatzker (1979). PDA in AP view is 170.2°; in the lateral view is 90.0°

On the seventh day in the conditions of the AEF distraction module, after the reduction of the edema, the operation of closed distraction osteosynthesis of the knee joint with an external fixation device, open reduction of the tibia, osteosynthesis with a support plate and the use of bone autoplasty was performed through the proposed lateral L-shaped access (**Fig. 3**).

For reduction of the fragments, the lateral condyle was elevated; a defect in the bone tissue was formed in the area of the proximal metaphysis of the tibia for the repair of which bone was harvested from the iliac wing crest. A T-shaped support plate was used for final fixation of the fracture. The congruence of the articular surfaces of the knee joint was restored. The AEF distraction module was dismantled. Discomfort during the implementation of the rehabilitation program was minimal. The range of the knee joint motion on the second day after the operation is shown in **Fig. 4**.

After 24 months, the patient arrived for a routine examination. Clinical and radiological study was performed. The follow-up radiographs showed a satisfactory position of bone fragments (**Fig. 5**). The range of motion in the knee joint 24 months after the operation is shown in **Fig. 6**.

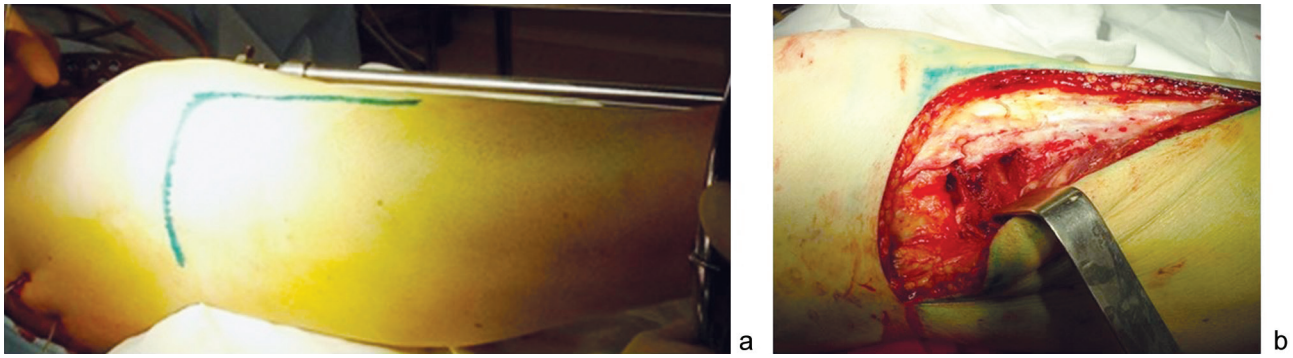

Fig. 3 Photos taken in the operating room: the cut line is marked with a solution of brilliant green on the patient's skin (a) and surgical approach to the damaged condyle of the right tibia after dissection of the skin, subcutaneous tissue, fascia and muscles under the conditions of distraction AEF (b)

Fig. 4 Range of knee joint motion in patient R., 55 years old, on the second day after the operation. Sufficiently painless movements in the knee joint were achieved

Fig. 5 Radiographs of the knee joint in patient P., 55 years old, in AP view (a) and lateral view (b) at 24 months after the operation: congruence of the articular surfaces was achieved, no secondary impression was noted. FTA in AP projection is equal to 176.5°; in the lateral view is 90.4°

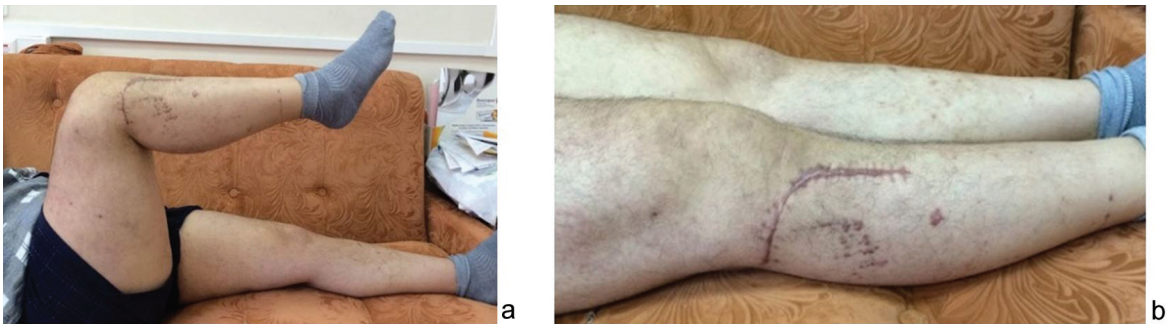

Fig. 6 Range of knee joint motion in patient R., 57 years old, 24 months after the operation

CONCLUSION

Improved diagnostic measures, practical systematization of injuries, algorithms of clinical diagnostic search that determine the tactics of managing patients at admission and at a clinical department,

consecutive use of transosseous and internal osteosynthesis, rational techniques of joint replacement, new technologies of osteosynthesis with differentiated choice of metal fixators, a modified proximal femoral metal fixator, accesses to joints, methods of defect plasty in combination with the method of perioperative management of patients and early active rehabilitation are components of success in the treatment of severe peri- and intraarticular fractures of the lower limb bones.

Introduction of the system of surgical treatment of intra- and periarticular fractures developed on the principles of anatomical and roentgenometrical recovery of the lower limb parameters, current methods of examination, new osteosynthesis technologies and improved arthroplasty techniques into clinical practice enabled to achieve excellent and good anatomic and functional results in the main subgroups as compared with the control ones in each of the fracture locations studied.

REFERENCES

1. Golubev V.G., Iulov V.V., Lapynin P.V., Sekirin A.B., Shishkin V.B., Krupatkin A.I. Reabilitatsiia patsientov s oskol'chatymi vnutrisustavnymi perelomami dlinnykh trubchatykh kostei [Rehabilitation of patients with comminuted intraarticular fractures of long tubular bones]. *Mediko-sotsial'naia Ekspertiza i Reabilitatsiia*, 2010, no. 3, pp. 41-44. (In Russian)
2. Gilev M.V. Khirurgicheskoe lechenie vnutrisustavnykh perelomov proksimal'nogo otdela bol'shebertsovoi kosti [Surgical treatment of intra-articular tibial plateau fractures]. *Genij Ortopedii*, 2014, no. 1, pp. 75-81. (In Russian)
3. Hunziker E.B. Articular cartilage repair: basic science and clinical progress. A review of the current status and prospects. *Osteoarthritis Cartilage*, 2002. Vol. 10, No 6. P. 432-446. DOI: 10.1053/joca.2002.0801.
4. Mauffrey C., Vasario G., Battiston B., Lewis C., Beazley J., Seligson D. Tibial pilon fractures: a review of incidence, diagnosis, treatment, and complications. *Acta Orthop. Belg.*, 2011, vol. 77, no. 4, pp. 432-440.
5. Kutepov S.M., Gilev M.V., Antoniadi Iu.V. Oslozhneniia pri khirurgicheskom lechenii vnutrisustavnykh perelomov proksimal'nogo otdela bol'shebertsovoi kosti [Complications in surgical treatment of intra-articular proximal tibial fractures]. *Genij Ortopedii*, 2013, no. 3, pp. 9-12. (In Russian)
6. Pomogaeva E.V. Voprosy terminologii i klassifikatsii vnutrisustavnykh perelomov distal'nogo otdela kostei goleni [Problems of terminology and classification of intra-articular fractures of the distal leg bone fratures]. *Vestnik Ural'skoi Meditsinskoi Akademicheskoi Nauki*, 2015, no. 4 (55), pp. 132-138. (In Russian)
7. Barei D.P., Nork S.E., Mills W.J., Coles C.P., Henley M.B., Benirschke S.K. Functional outcomes of severe bicondylar tibial plateau fractures treated with dual incisions and medial and lateral plates. *J. Bone Joint Surg. Am*., 2006, vol. 88, no. 8, pp. 1713-1721. DOI: 10.2106/JBJS.E.00907.
8. Shumaev D.N., Shagalin G.A. Rezul'taty lecheniia bol'nykh s perelomami pilona [Results of treating patients with pilon fractures]. *Biulleten' Meditsinskikh Internet-konferentsii*, 2015m vol. 5, no. 5, pp. 864. (In Russian)
9. Bansal M.R., Bhagat S.B., Shukla D.D. Bovine cancellous xenograft in the treatment of tibial plateau fractures in elderly patients. *Int. Orthop*., 2009, vol. 33, no. 5, pp. 779-784. DOI: 10.1007/s00264-008-0526-y.
10. Bauer T.W., Muschler G.F. Bone graft materials. An overview of the basic science. *Clin. Orthop. Relat. Res.*, 2000, no. 371, pp. 10-27.
11. Coughlin M.J., Mann R.A., Saltzman C.L. *Surgery of the Foot and Ankle.* 8th ed. Vol. II, Part X. Ch. 36.: Trauma: Pilon Fractures. Philadelphia, Mosby Elsevier, 2007.
12. Yetkinler D.N., McClellan R.T., Reindel E.S., Carter D., Poser R.D. Biomechanical comparison of conventional open reduction and internal fixation versus calciumphosphate cement fixation of a central depressed tibial plateau fracture. *J. Orthop. Trauma*, 2001, vol. 15, no. 3, pp. 197-206.
13. Antoniadi Iu.V., Chernitsyn D.N., Volokitina E.A., Zverev F.N., Zhiriakov D.L. *Sposob lecheniia perelomov proksimal'nogo otdela bedra v usloviiakh osteoporoza* [The way of treatment of proximal femoral fractures under osteoporosis conditions]. Patent RF, no. 2473317, 2013. (In Russian)
14. Antoniadi Iu.V., Kozlov V.A., Zverev F.N., Volokitina E.A. *Intramedulliarnyi gamma-sterzhen'* [The intramedullary gamma rod]. Utility model Patent RF, no. 154108, 2015.
15. Gilev M.V., Antoniadi Iu.V., Volokitina E.A., Chernitsyn D.N., Zhiriakov D.L. *Khirurgicheskii dostup k naruzhnomu myshchelku bol'shebertsovoi kosti dlia osteosinteza pri perelomakh* [The surgical approach to the lateral tibial condyle when performing osteosynthesis for fractures]. Patent RF, no. 2525211, 2014. (In Russian)
16. Pomogaeva E.V., Antoniadi Iu.V., Chernitsyn D.N., Zhiriakov D.L., Zverev F.N., Volokitina E.A. *Sposob vremennoi fiksatsii vnutrisustavnykh perelomov distal'nogo otdela kostei goleni* [The way of temporary fixation for intra-articular fractures of the distal leg bones]. Patent RF, no. 2564080, 2015. (In Russian)
17. Gilev M.V., Antoniadi Iu.V., Volokitina E.A., Pomogaeva E.V. *Sposob otkrytoi repozitsii i osteosinteza perelomov distal'nogo otdela kostei goleni* [The way of open reposition and osteosynthesis of distal leg bone fractures]. Patent RF, no. 2623298, 2017. (In Russian)
18. Chelnokov A.N., Bekreev D.A. Intramedulliarnyi osteosintez pri perelomakh verkhnei treti bol'shebertsovoi kosti – tekhnika na osnove chreskostnogo osteosinteza [Intramedullary osteosynthesis for fractures of the upper tibial third – a technique based on transosseous osteosynthesis]. *Genij Ortopedii*, 2011, no. 2, pp. 102-106. (In Russian)
19. Tejwani N., Polonet D., Wolinsky P.R. Controversies in the intramedullary nailing of proximal and distal tibia fractures. *J. Am. Acad. Orthop. Surg.*, 2014, vol. 22, no. 10, pp. 665-673. DOI: 10.5435/JAAOS-22-10-665.
20. Meena R.C., Meena U.K., Gupta G.L., Gahlot N., Gaba S. Intramedullary nailing versus proximal plating in the management of closed extra-articular proximal tibial fracture: a randomized controlled trial. *J. Orthop. Traumatol.*, 2015, vol. 16, no. 3, pp. 203-208. DOI: 10.1007/s10195-014-0332-9.
21. Gilev M.V., Volokitina E.A., Antoniadi Iu.V., Zverev F.N., Chernitsyn D.N., Zhiriakov D.L. Khirurgicheskoe lechenie dvukhmyshchelkovykh perelomov bol'shebertsovoi kosti [Surgical treatment of bicondylar tibial fractures]. *Khirurgiia. Zhurnal im. N.I. Pirogova*, 2017, no. 1, pp. 68-72. (In Russian)

Received: 29.12.2017

Information about the author:

Yuri V. Antoniadi, M.D., Ph.D.,
Ural State Medical University, Ekaterinburg, Russian Federation,
Email: usma@usma.ru