IOP Conf. Series: Materials Science and Engineering **412** (2018) 012078 doi:10.1088/1757-899X/412/1/012078

Biomechanical assessment of outputs of surgical treatment of patients with complex fragments of lower limbs

B I Vahitov[1], I O Pankov[2], I Kh Vahitov[1], V R Nagmatullin[2] and L I Vahitov[1]

[1]Kazan Federal University, Russian Federation, Kazan, 18 Kremlin Street, 420008
[2]Kazan State Medical Academy, Russian Federation, Kazan, 36 Butlerova Street, 420012

tggpy-mbofk@mail.ru

Abstract. Studies of static-dynamic disorders, with the use of new, progressive technologies in the post-traumatic period becoming increasingly practical. We conducted studies of the support, dynamic function of the lower limbs, balance in a vertical rack in 20 healthy individuals (comparison group) in order to determine the normal values of the biomechanical research indices. Of all studied women 12, men 8. All subjects were of working age (25-55 years). The median age was 40 years. Of particular interest are data from biomechanical studies of the support, dynamic function of the lower extremities, sensory balance, conducted in 18 patients with fractures of the joint region of the lower leg bones in the dynamics at terms 9-12 and 18-24 months after the operation. In the study of the balance, there were found disturbances in the influence of the somatosensory, visual and vestibular systems on maintaining the balance of the body. Each balance study included a series of open and closed eyelids in a vertical patient stand with lower limbs straight in the knee joints on hard and soft (foamy) surfaces. The application of the hardware-software evaluation of the support-dynamic function of the lower extremities by the type of stabilometry at the rehabilitation stages will allow to identify and carry out the prevention of serious post-traumatic complications at an early stage of the disease.

Introduction

Restoration of patients with intra-articular fractures of the lower limbs is one of the most urgent problems of traumatology and orthopedics at all stages of treatment [1, 2]. Complications and unsatisfactory outcomes of treatment for intraarticular fractures of the bones of lower extremities, according to various authors, reach 30.0% and higher [3, 4]. The most frequent and severe among them are the development of deforming arthrosis and persistent contractures of the joints, disrupting the function of the entire lower limb and leading to a significant decrease in the quality of life [5,6].

Thus, despite the variety of methods and methods of early recovery of intraarticular bone fractures of the lower limbs, a large number of works devoted to improving outcomes, the problem of treating such injuries can not be considered finally solved, which is confirmed by a high percentage of complications and adverse outcomes among patients. In connection with the above, we have attempted to develop a system of diagnostic measures, as well as an integrated approach to the rehabilitation of patients with complex fractures of the lower limbs [7, 8].

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

Materials and methods of research

Biomechanical studies of the lower extremities in norm, as well as at the stages of restorative treatment of patients with fractures of the knee and ankle joint area were carried out on the NeurocomBalanceMaster® hardware-software version 7.0. The most important components of the BalanceMaster® system are the computer and the platform mounted on the base. When performing this study, the patient stands on the double plate of the platform facing the monitor. The motion sensors under the platform measure vertical movements caused by the pressure of the patient's feet. On the cable, this information is transferred from platform to computer. The computer receives the measurement data from the platform, analyzes the information and generates a display on the screen (Figure 1).



Fig.1. The BalanceMaster® system (NeuroCom® International, Inc.) (general view).

When carrying out biomechanical studies, three types of tests were performed to identify the supporting and dynamic function of the lower extremity, the balance in the vertical rack (holding the body weight, walking with a roll - determining the length of the step, the step width, step speed, and the modified clinical test of sensory interaction of the balance). These studies allow an objective assessment of posttraumatic disorders of the function of the lower extremities, as well as trace the recovery process in the process of medical rehabilitation.

We conducted studies of the support, dynamic function of the lower limbs, balance in a vertical rack in 20 healthy individuals (comparison group) in order to determine the normal values of the biomechanical research indices. Total number of women was 12, men 8. All subjects were of working age (25-55 years). The median age was 40 years.

Statistical processing of the data was carried out using the SPSS software package (v. 13.0). The differences in the quantitative indicators of the two groups were estimated using the Student's test.

Of particular interest are data from biomechanical studies of the support, dynamic function of the lower extremities, sensory balance, conducted in 18 patients with fractures of the joint region of the lower leg bones in the dynamics at terms 9-12 and 18-24 months after the operation.

The data of biomechanical studies of the supporting, dynamic function of the lower extremities, the sensory balance in the vertical rack in patients with complex fractures of the lower extremities at the stages of medical rehabilitation in the dynamics at the periods 9-12 and 18-24 months after the operation are presented in Tables 1, 2 and 3.

Table 1 presents the comparative data of the Weight Bearing / Squat test (Weight retention) in patients after surgical treatment at terms 9-12 and 18-24 months after surgical treatment.

Table 1 - Weight Bearing / Squat (Weight retention) test results in patients at terms 9-12 and 18-24 months after surgical treatment.

Weight retention test	9-12 months	18-24 months
% Difference in position 0^0	10,2±2,0	10,2±3,0
% в Difference in position 30^0	11,4±2,0	11,5±3,0*
% Difference in position 60^0	12,4±3,0	12,8±4,0*
% Difference in position 90^0	13,2±2,0	14,2±2,0*

*Notation: * - statistically significant difference (P <0.001) from the indices to the treatment.*

Table 2 shows the walking with transition test results (WalkAcross (WA)) in patients at terms 9-12 and 18-24 months after surgery.

Table 2 - Data of walking with transition test (WalkAcross (WA)) in patients at terms 9-12 and 18-24 months after surgical treatment.

Test Parameters for walking with transition	9-12 months	18-24 months
Step width (cm.)	26,8±2,5	2,8±2,6*
Step length (cm.)	62,2±4,7	62,1±2,8*
Step speed (cm./sec.)	76,7±6,7	68,4±6,6*
Symmetry of step (%)	5,4±2,0	5,4±3,0*

*Notation: * - statistically significant difference (P <0.001) from the indices to the treatment.*

The results of the sensory balance interaction test (CTSIB (mCTSIB) in patients at terms 9-12 and 18-24 months after surgical treatment are presented in Table 3.

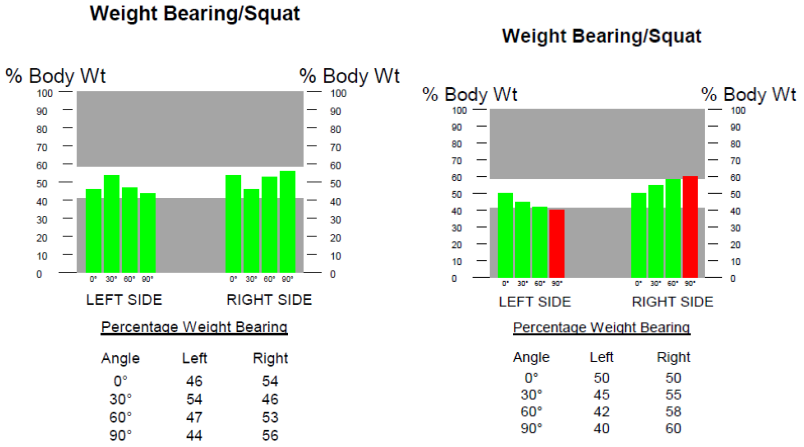
Table 3 - Data obtained from the modified sensory balance interaction clinical test (CTSIB (mCTSIB) in patients at terms 9-12 and 18-24 months after surgical treatment.

Parameters of sensory balance interaction test	9-12 months	18-24 months
Firm-EO (deg/sec)	0,26±0,2	0,26±0,2*
Firm-EC (deg/sec)	0,36±0,3	0,36±0,6*
Foam-EO (deg/sec)	0,64±0,3	0,66±0,3*
Foam-Ec (deg/sec)	1,53±0,2	1,56±0,2*

*Notation: * - statistically significant difference (P <0.001) from the indices to the treatment.*

According to the data of biomechanical studies conducted in patients with complex fractures of the lower limbs, carried out in the dynamics at the intervals of 9-12 and 18-24 months after surgical treatment, presented in Tables 1, 2 and 3, there is a tendency to a certain decrease in the parameters of the reference, dynamic function lower limb, a modified sensory balance in a vertical rack.

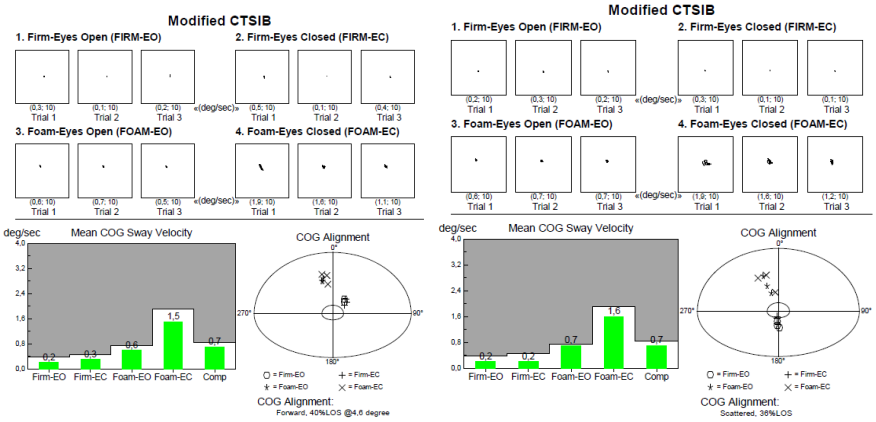
Figure 2 presents the comparative data of the study of the support function of the lower extremities of patient B., born in 1975, No. 2467, treated at the clinic of traumatology of the Republican Clinical Hospital with the diagnosis: closed fracture of both ankles, marginal fracture of the posterior edge of the tibia, distal interstice syndesmosis, dislocation of the foot behind and outside, in dynamics at terms 10 and 24 months after surgical treatment.



a). b).

Figure 2 - Data of the study of the supporting function of the lower limbs of patient B., born in 1975. through 10 (a) and 24 (b) months after the operation in comparison.

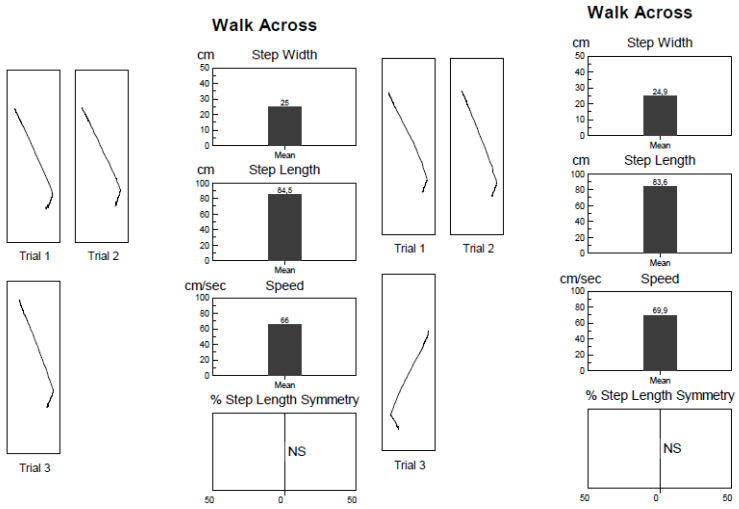
Figure 3 presents the comparative data of the study of the sensory balance in the vertical column of the same patient in dynamics at terms 10 and 24 months after surgical treatment.



a). b).

Figure 3 - The data of the study of sensory balance in the vertical rack of the patient B., born in 1975 through 10 (a) and 24 (b) months after the operation in comparison.

Figure 4 presents the comparative data of the study of the dynamic function of the lower extremities of patient B., born in 1975, No.2467 in dynamics at terms 10 and 24 months after surgical treatment.



a). b).

Figure 4 - Data of the study of the dynamic function of the lower limbs of patient B., born in 1975. through 10 (a) and 24 (b) months after the operation in comparison.

As follows from the above comparative data of biomechanical studies of the function of the lower extremities in dynamics at terms 10 and 24 months after the operation, the patient experienced a decrease in the support function, with insignificant decreases in sensory balance and dynamic function of the lower limbs in the long-term after trauma. These disorders can be associated with the onset of the development of posttraumatic deforming arthrosis due to the primary severe damage to the capsular-ligament apparatus of the ankle.

Conclusions

The data of biomechanical studies carried out on the NeurocomBalanceMaster® 7.0 system reveal, before the manifest clinical manifestations of varying degrees of severity, various minor disorders of the support (uneven distribution of loads on the left and right lower limbs), dynamic function (decrease in length, increase in the width of the step on the damage side) sensory balance in a vertical rack in the early and distant periods after surgical treatment, which indicates a developing post-traumatic pathology in the form of deformities iruyuschego arthrosis.

The application of the hardware-software evaluation of the support-dynamic function of the lower extremities by the type of stabilometry at the rehabilitation stages will allow to identify and carry out the prevention of serious post-traumatic complications at an early stage of the disease.

References

[1] Davydov O D, Montile A I, Marchuk Y V 2012 *A new way to diagnose the functional state of the musculoskeletal system based on the results of stabilographic studies* Collected theses of the III Congress of Traumatology-Orthopedists of the Ural Federal District "Chaklinsky Readings". – Ekaterinburg pp 45-47

[2] Ryabchikov I V, Pankov I O 2013 *Evaluation of the dynamic function of the lower extremities of patients after surgical treatment of fractures of the distal articular region of the lower leg bones in the process of restorative treatment* Elektr. sci. Journal of Contemporary Problems of Science and Education

[3] Pankov I O, Ryabchikov I R 2013 *Changes in the dynamic function of the lower extremity of patients after surgical treatment of fractures of the distal joint region of the lower leg bones during medical rehabilitation* Elektr. sci. Journal of Contemporary Problems of Science and Education

[4] Pankov I O, Ryabchikov I R 2014 *Our experience in restoring the supporting, dynamic function of the lower extremity, the balance of patients with complex fractures of the distal joint region of the lower leg bones* Elektr. sci. Journal of Contemporary Problems of Science and Education

[5] Ryabchikov I V, Pankov I O 2013 *Evaluation of the impact of medical rehabilitation on the restoration of the dynamic function of the lower limbs of patients after surgical treatment of fractures of the ankle area* Elektr. sci. Journal of Contemporary Problems of Science and Education
[6] Arkhipov L K, Lychagin A V 2000 *Modern aspects of the treatment of posttraumatic deforming arthrosis of the ankle joint* Vestnik travmatol. and orthop. them. N. N. Priorov V 4 pp 64-67
[7] Yu V Antoniadi, Berdyugin, Galyautdinov A F 2006 *Modern technologies in the fracture of the ankles* Traumatology and orthop. Russia No 2 pp 22
[8] Babelo O Yu, Sviridov A I, Bobrova O V 2002 *The device of its own design for the treatment of ankle joint damage* Materials of the VII Congress of Traumatologists-Orthopedists of Russia V 2 pp 387-8