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High Valgus Tibial Osteotomy in the Complex Treatment of Anterior Cruciate ligament Ruptures in Patients With Varus Gonarthrosis of the Knee

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MATERIALS AND METHODS We observed 164 patients from 2013 to 2019 (mean age 39.8 ± 5.1 years) who underwent anatomical antegrade ACLR BTB autograft. Group 1 (43 people, 31.1%) and Group 2 (48 patients, 29.3%) included patients with isolated medial GA of 2-3 degree and/or varus deformity of at least 5°. Group 3 (73 people or 44.5%) included patients with normal articular cartilage and the correct axis of the limb. In Group 1, ACLR was supplemented with an "open wedge" HVTO. The assessment was carried out according to Lysholm Knee Scoring Scale, 2000 IKDC, KOOS.

RESULTS The simultaneous performance of HVTO and ACLR shows good clinical and radiological results in 93% in the first year, and three years after surgery keeps it in 88.4%. The results of treatment of patients of Group 1 turned out to be significantly better in comparison with Group 2 ($p<0.01$). In Group 1, the anteroposterior and rotational hypermobility of the knee joint was 16.3%, less commonly we observed pain, synovitis, atrophy of the muscles of the thigh and contracture ($p <0.01$), some dysfunctions (C according 2000 IKDC scale) were determined in 11.6% ($p<0.05$), and significant impairment of the knee joint function (D according to 2000 IKDC scale) were not observed ($p<0.001$). In the first 5 years after surgery, a much larger number of patients of the 1st group were able to fully return to their work, domestic and sports activities, compared with Group 2 ($p<0.05$).

CONCLUSION The combined ACLR and HVTO allow reliable technology in the treatment of anterior instability in patients with GA ($p< 0.05\%$). This approach is effective in young active middle-aged patients, with anterior instability of the knee joint and varus GA or prerequisites for its development, as well as with revision ACLR, posterior tibial plateau tilt of more than 12°. Performing HVTO simultaneously with ACLR is not practical for patients with valgus deviation of the lower leg, failure of the posterolateral capsular ligamentous complex, or changes in the external joint.

Keywords: ACL rupture, gonarthrosis and instability of the knee joint, high valgus osteotomy of the tibia

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ACL — anterior cruciate ligament
BTB — bone-tendon-bone (autograft)
GA — gonarthrosis
HVTO — high valgus tibial osteotomy
IKDS — International Knee Documentation Committee Score
KOOS — Knee Injury and Osteoartritis Outcome Score
rACL — reconstruction of anterior cruciate ligament

INTRODUCTION

Anterior cruciate ligament (ACL) ruptures continue to be one of the most common knee injuries. The frequency of these injuries is growing steadily: in 2000, experts noted 30 cases per 100,000 population, and in 2016, already 68.6 cases per 100,000 [1, 2]. The majority of these patients (65.8–90.1%) undergo arthroscopic ACL reconstruction (rACL) [3]. In 56% of cases, surgical treatment is carried out no earlier than 6 months after injury [4]. About 66% of rACL is performed against the background of already existing degenerative changes in the articular cartilage, which is often explained by long-term chronic anterior knee instability [5–7]. Also, some patients by the time of ACL rupture already have individual signs of arthrosis, including varus deformity of the knee joint. In such cases, the mechanical axis of the limb is displaced inwards and the ACL graft placed in the joint will experience overload and damage, with the risk of its subsequent failure [8]. One of the methods of treating the early stages of medial gonarthrosis (GA) is high valgus tibial osteotomies (HVTO), which redistribute the load on the outer parts of the joint by correcting the axis of the limb [9]. Thus, the established ACL graft can be "protected" [10, 11]. However, indications and algorithms for choosing a specific technique for corrective osteotomy in simultaneous operations with rACL remain uncertain.

Aim of study: on the basis of a comparative analysis of the clinical and radiological results of simultaneous rACL and HVTO of the "open wedge" type, to determine its effectiveness, indications and contraindications for use.

MATERIAL AND METHODS

From 2013 to 2019, 164 patients underwent anatomical antegrade rACL for clinically significant anterior knee instability. The age of the operated patients ranged from 36 to 52 years (average 39.8 ± 5.1 years).

Patient complaints and knee joint function were assessed using the Lysholm Knee Scoring Scale, 2000 IKDC, KOOS. Standard clinical examination and radiological diagnostics (X-ray of the knee joint in standard projections, teleradiography of the lower extremities, magnetic resonance imaging (MRI) and / or computed tomography (CT)) were performed. At the same time, special attention was paid to the stability and range of motion of the knee joint, the dynamics of the development of osteoarthritis, the mechanical axis of the lower extremities, the value of the posterior slope of the articular surface of the tibia. The duration of the operating time, the duration of inpatient treatment after surgery, the total period of disability, as well as the timing of returning to physical activity and sports were studied.

The selection criteria for the 1st and 2nd groups were the presence of isolated medial GA of grade 2-3 in patients, including GA against the background of a stitched or partially resected internal meniscus and / or varus deformity of the limb at an angle of at least 5°. Group 3 included patients with normal articular cartilage.

The study did not include patients with signs of complex instability of the knee joint, degenerative or post-traumatic changes in the outer parts of the knee joint, patella and femur block, injuries of the outer meniscus, and autoimmune diseases accompanied by arthritis.

Group 1 included 43 patients (31.1%), where rACL was supplemented with open-wedge HVTO. Patients of the 2nd (48, 29.3%) and 3rd groups (73, 44.5%) underwent isolated anatomical antegrade rACL.

All groups were comparable in terms of gender, age, body mass index, mechanism and timing from the moment of injury (Table 1).

Table 1
Distribution of patients in study groups, n=164

Parameter	Group 1, n=43	Group 2, n=48	Group 3, n=73	p	p1
Male	24 (55.8%)	22 (45.8%)	34 (46.6%)	0.3582	0.3487
Female	19 (44.2%)	26 (54.2%)	39 (53.4%)	0.3559	0.3494
Mean age, years	34.7±0.3	34.1±0.7	35.2±0.2	0.4349	0.1424
Sport trauma	26 (60.5%)	23 (47.9%)	41 (56.2%)	0.03162	0.4686
Other mechanisms of trauma	17 (39.5%)	25 (52.1%)	32 (43.8%)	0.2944	0.4578
Presence of others joint lesions	40 (93.0%)	44 (91.6%)	46 (63.0%)	0.5410	0.1437
Time prior to surgery: up to 24 months	13 (30.2%)	15 (31.3%)	39 (53.4%)	0.5565	0.0861
from 24 to 36 months	30 (69.8%)	33 (68.8%)	34 (46.6%)	0.5473	0.1306

Notes: p — confidence probability of differences between Group 1 and Group 2; p1 — confidence probability of differences of Group 1 and Group 3

In all patients, ACL reconstruction was performed with a bone-tendon-bone autograft (BTB), which was formed from the middle portion of the patellar ligament with bone blocks, one of which had a trapezoidal shape.

Bone canals were positioned taking into account the centers of attachment of the native ACL. For the canal in the femur, this zone was determined at the lateral bifurcation ridge, below the lateral intercondylar ridge of the lateral condyle of the femur, and for the tibia, opposite the posterior cruciate ligament and lateral to the base of the medial eminence of the tibia.

The graft was pulled through the canal in the femur, wedging the trapezoidal bone block in it, and the distal bone block, after pulling the graft, was fixed in the tibial canal with one interference screw.

In patients of the 1st group, after the formation of bone canals, an open-wedge HTVO was performed. Osteotomy was performed distal to the tibial canal, after cutting and epiperiosteal separation of the external portion of the internal lateral ligament and abduction of the tendons of the semitendinosus and tender muscles. The cut through the tibia was carried out in an oblique direction along the guide wires, not reaching about 1 cm to the cortex of the outer condyle of the tibia. Under fluoroscopic guidance, the tibia was given a valgus position so that the mechanical axis of the lower limb passed through the Fujisawa point, corresponding to approximately 67.5% of the width of the tibial plateau, calculated from its medial edge. The new position of the limb was fixed with a plate with angular stability of the screws, positioned in the middle or posterior part of the tibia to exclude damage to the ACL graft. The area of the tibial bone defect was filled with an autograft from the wing of the ilium.

The stages of surgery in patients of group 1 are shown in Fig. 1.

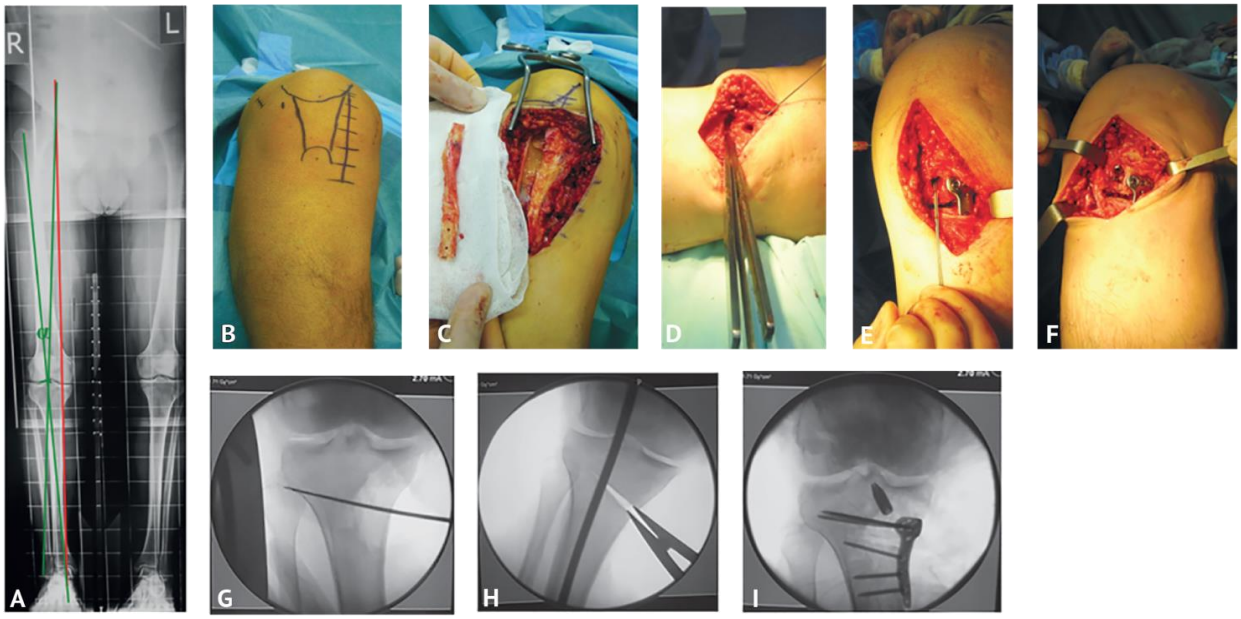

Fig. 1. Fig. 1 Stages of operation of patients of Group 1. A — preoperative planning. The mechanical axis of the limb (red line) and the determination of the angle of correction for hallux valgus deviation (angle between the green lines); B — the appearance of the knee joint before surgery; C — BTB transplant retrieval; D — osteotomy of the tibia; E — fixation of the corrected axis of the lower leg with a plate and screws, conducting a ACL transplant; F — the appearance of the knee joint after fixation of the ACL transplant; G — the choice of the level of osteotomy; H — determination of the angle of correction of deformation after osteotomy; I — the position of the implants after fixation of the osteotomy and the installation of the ACL graft

Postoperative management and rehabilitation in all groups was carried out according to the same standard technique used in patients after rACL. In addition, in patients of the 1st group, the axial load on the limb was limited during the first 2.5–3 months. Comparison of treatment results in groups was carried out 12 months later and not less than 36 months after surgery.

RESULTS

During one year of treatment in all groups, the functional results were significantly higher than before the operation. No infectious complications were observed, however, in 4 patients of the 1st group in the early postoperative period, soft tissue edema and subcutaneous hematoma along the inner and posterior surfaces of the leg were observed, while in one of these patients deep vein thrombosis developed, which required specific conservative treatment.

In the majority of patients of the 1st group, it was possible to improve the mechanical axis of the lower limb ($p < 0.001$) and at the same time, there was no clinically significant change in the angle of the posterior inclination of the articular surface of the tibia (on average, no more than 2.1º ± 0.9º), as well as maintain the range of active movements in the knee joint. At the same time, the osteotomy zone healed in the middle (Table 2).

Table 1

The results of surgical treatment of patients of Group 1 (12 months after surgery, n = 43)

Evaluation Criteria (mean)	Before surgery	After operation	p
The mechanical axis of the limb, º	7.1 ± 2.1	-1.3 ± 1.7	< 0.001
Plateau tilt angle of tibia, º	8.7 ± 1.8	10.1 ± 0.6	0.123
Volume of active movements	136.1 ± 4.5	137.3 ± 4.9	0.357
Lysholm Knee Scoring Scale	54.9 ± 8.2	95.8 ± 4.7	0.001
2000 IKDC			
A	0	18 (41.9%)	0.001
B	8 (18.6%)	22 (51.2%)	0.02
C	24 (55.8%)	3 (6.9%)	0.001
D	11 (25.6%)	0	0.001
KOOS			
Pain (average score)	53.2 ± 2.1	85.3 ± 3.2	0.001

Symptoms (average score)	49.1 ± 3.5	87.5 ± 2.6	0.001
Daily activity (average score)	59.1 ± 2. 3	87.6 ± 1.5	0.001
Sports activity (average score)	49.2 ± 1.9	73.3 ± 2.7	0.001
Quality of life (average score)	58.1 ± 3.7	87.6 ± 2.3	0.001
Lachman test			
0	0	28 (65.1%)	0.001
1+	4 (9.3%)	13 (30.2%)	0.03
2+	26 (60.5%)	2 (4.7%)	0.001
3+	13 (30.2%)	0	0.001
Anterior Drawer Test			
0	0	34 (79.1%)	0.001
1+	4 (9.3%)	7 (16.3%)	0.299
2+	29 (67.4%)	2 (4.7%)	0.001
3+	10 (23.3%)	0	0.001
Pivot Shift Test			
0	0	29 (67.4%)	0.001
1+	4 (9.3%)	11 (25.6%)	0.08
2+	30 (69.8%)	3 (6.9%)	0.001
3+	9 (20.9%)	0	0.001

p - confidence probability of differences in the group before and after surgery

When studying the stability of the knee joint, only 2 patients (4.7%) had a positive result for the Lachman test and the "anterior drawer" corresponding to a conditional score of 2+, and in 3 patients (6.9%) rotational instability was observed in the form of Pivot Shift-test 2+ (see Table 1).

In group 2, the Lachman test at the 2+ level was noted in 7 patients (14.6%), and in one (2.1%) it corresponded to the conditional score of 3+. The Pivot shift test at the 2+ level was recorded in 4 of them (8.3%), and in 2 more patients (4.2%), good indicators of anteroposterior stability were noted. The average value of varus deformity of the knee joint one year after surgery in patients of the 2nd group was 6.1 ± 0.4º.

In the 3rd group of patients with anteroposterior or rotational instability of the knee joint, results below the conditional score of 1+ were not observed.

The duration of surgical intervention in patients of group 1 was 37.4 ± 8 minutes longer than in patients of groups 2 and 3. The duration of hospital stay, rehabilitation, terms of disability and return to sports in the groups did not differ.

Assessment of the final results of surgical treatment of patients after 36 months showed that the function of the knee joint in groups 1 and 3 was much better than in group 2. They were less likely to have persistent pain syndrome, synovitis, atrophy of the thigh muscles and contractures ($p < 0.01$). It should be noted that in these groups, some joint dysfunction (C on the 2000 IKDC scale) was observed only in 11.6% ($p < 0.05$) and 6.8% ($p < 0.001$) cases, respectively. No significant dysfunctions of the knee joint (D on the 2000 IKDC scale) were detected ($p < 0.001$). At the same time, there were no statistically significant differences between the 1st and 3rd groups according to 2000 IKDC, as well as according to the Lysholm Knee Scoring Scale (Table 3).

Table 3
Results of surgical treatment of patients in groups 3 years after the operation, n=164

Evaluation criterion	Group 1, n = 43	Group 2, n = 48	Group 3, n = 73	p	p1	p2
The mechanical axis of the limb (average)	1.1 ± 1.3	8.3 ± 2.6	1.4 ± 1.2	p <0.001	p <0.001	p = 0.782
Plateau tilt angle bones (average	9.3 ± 1.3	10.7 ± 2.1	10.1 ± 1.9	p = 0.245	p = 0.561	p = 0.648
Volume of active movements (average)	132.1 ± 2.4	120.6 ± 2.5	134.3 ± 1.1	p <0.01	p <0.01	p = 0.952
Lysholm Knee Scoring Scale (average)	91.4 ± 3.3	78.6 ± 3.7	96.1 ± 2.2	p <0.01	p <0.01	p = 0.753
2000 IKDC						
A	16 (37.2 %)	5 (10.4 %)	38 (52.1%)	p <0.01	p <0.001	p = 0.219
B	22 (51.2 %)	9 (18.8 %)	30 (41.1%)	p <0.01	p <0.05	p = 0.316
C	5 (11.6 %)	23 (47.9 %)	5 (6.8%)	p <0.05	p <0.001	p = 0.314
D	0	11 (22.9 %)	0	p <0.001	p <0.001	-
KOOS (Average score)						
Pain	85.8 ± 2.8	69.1 ± 1.2	92.1 ± 3.0	p <0.01	p <0.001	p <0.05
Symptoms	88.1 ± 2.2	50.4 ± 2. 7	93.8 ± 3.3	p <0.001	p <0.001	p = 0.279
Daily activity	91.3 ± 2.7	71.3 ± 2, 2	96.7 ± 3.1	p <0.001	p <0.001	p = 0.367
Sports activity	80.9 ± 2.9	62.4 ± 3.1	89.6 ± 3.7	p <0.001	p <0.01	p <0.05
The quality of life	89.4 ± 3.1	67.6 ± 2.4	94.8 ± 2.6	p <0.001	p <0.001	p = 0.127
Lachman test						
0	19 (44.2%)	7 (14.6%)	39 (53.4%)	p < 0.016	p <0.001	p = 0.349
1+	16 (37.2%)	10 (20.8%)	27 (37.0%)	p = 0.144	p = 0.564	p = 0.113
2+	8 (18.6%)	22 (45.8%)	7 (9.6%)	p <0.037	p <0.00 1	p = 0.174
3+	0	9 (18.8%)	0	p <0.005	p <0.001	-
Anterior Drawer Test						
0	31 (72.1%)	12 (25.0%)	45 (61.6%)	p <0.005	p <0.01	p = 0.356
1+	8 (18.6%)	11 (22.9%)	20 (27.4%)	p = 0.439	p = 0.416	p = 0.269
2+	4 (9.3%)	16 (33.3%)	8 (11.0%)	p = 0,021	p = 0.013	p = 0.532
3+	0	9 (18.8%)	0	p <0.005	p <0.001	-
Pivot Shift Test						
0	21 (48.8%)	4 (8.3%)	41 (56.2%)	p <0.001	p <0.001	p = 0.399
1+	16 (37.2%)	12 (25.0%)	29 (39.7%)	p = 0.242	p = 0.157	p = 0.504
2+	5 (11.6%)	21 (43.8%)	3 (4.1%)	p <0.005	p <0.001	p = 0.146
3+	1 (2.3%)	11 (22.9%)	0	p <0.005	p <0.001	p = 0.376

The degree of gonarthrosis						
0	0	0	36 (49.3%)	-	p <0.001	p <0.001
I	0	0	2 9 (39.7%)	-	p <0.001	p <0.001
II	16 (37.2%)	2 (4.2%)	8 (11.0%)	p <0.001	p <0.005	p = 0.188
III	24 (55.8%)	32 (66.7%)	0	p = 0.364	p <0.001	p <0.001
IV	3 (7.0%)	14 (29.2%)	0	p <0.05	p <0.001	p <0.001

Notes: p — confidence probability of differences between Group 1 and Group 2; p1 — confidence probability of differences of Group 3 and Group 2; p2 — confidence probability of differences of Group 1 and Group 3

At the same time, the patients of the 1st group, in comparison with the 3rd group, more often complained of pain, which arose mainly after an intense load on the operated limb and was of episodic and short-term. Pain was the main factor contributing to the decrease in sports activity in these patients ((p <0.05) on the KOSS scale, see Table 3).

The stability of the knee joint, both anteroposterior and rotational, was higher in patients of groups 1 and 3 (p <0.001). Moreover, the groups did not differ statistically significantly.

In the 2nd group, patients with a significant Lachman test were more often identified, which corresponded to the conditional score of 2+: in 22 (45.8%) versus 8 (18.6%) and 7 (9.6%) in the 1st (p <0.037) and 3rd (p <0.001) groups, respectively. Lachman's and "front drawer" tests corresponding to 3+ were observed only in patients of the 2nd group: 9 (18.8%), ((p <0.005), see Table 2).

A clinically significant Pivot Shift test (2+ and 3+ conditional points), characterizing the rotational stability of the knee joint, was observed in group 2 in 21 (43.8%) and 11 (22.9%) cases, respectively ((p <0.005), see Table 2).

Along with a decrease in stability and deterioration of the functional state in the 2nd group, progression of arthritic changes in the knee joint to grade 3 (in 32 patients, 66.7%) and grade 4 (in 14, 29.2%, p <0.05), respectively, were observed. Thirty six months after rACL, grade 2 GA was diagnosed only in 2 patients (4.2%) of this group (p <0.001). The average displacement of the mechanical axis of the limb inward in these patients was 8.3 ± 2.6º compared with the 1st and 3rd groups (p <0.001), and in the 1st group the medialization of the mechanical axis of the limb did not exceed 3º on average (see Table 2).

Three years after surgery, 6 patients (12.5%) of the 2nd group underwent total cement knee arthroplasty, and 5 years later, replacement of the knee joint with an artificial one was performed in another 21 patients (43.8%).

The time spent by the patients of the 1st group in the operating room was, on average, 32.7 ± 2 minutes longer than in the 2nd and 3rd groups. The duration of inpatient treatment, the duration of rehabilitation, the total period of incapacity for work, the timing of returning to physical activity and sports in the groups did not differ.

DISCUSSION

In the course of the study, it was found that the simultaneous performance of open-wedge-type HTVO and rACL allows to achieve good clinical and radiological results in 93% (40 patients) in the first year after surgery, and after three years - to maintain it in 88.4 % (38 patients). This approach is justified in patients with signs or risks of developing varus GA [12].

In our study, the results of surgical treatment of patients in group 1, obtained using the main integral scales, were not only higher than before surgery, but also significantly better in comparison with patients in group 2 (p <0.01). The expediency of simultaneous correction of the limb axis and restoration of the anterior stability of the knee joint has been confirmed by other authors [13, 14]. At the same time, according to X-ray data, 10 patients (23.3%) were diagnosed with signs of progression of varus GA. The frequency of such changes, according to the modern literature, is quite variable and ranges from 0 to 22% [15, 16]. The situation is similar with regard to the assessment of knee joint stability. In our study, the signs of anteroposterior and rotational hypermobility of the knee joint in patients of group 1 were 16.3% (7 observations), which is close to the results obtained by C. Jin et al. (17%). Thus, it is advisable to supplement the "anatomical" ACL plasty in patients with predictably long-term high loads and demands on the function of the knee joint: in young and middle-aged people, in active lifestyles, and in athletes, if they have anterior instability of the knee joint, elements of varus GA or individual prerequisites for its development. These factors include late rACL (more than 12 months after its injury), varus deviation of the lower leg by more than 5°, absence or destruction of the internal meniscus, the presence of areas of post-traumatic cartilage damage or chondromalacia in the loaded zones of the femoral condyles and tibia.

The state of the ACL graft and the stability of the knee joint are affected by the angle of the posterior inclination of the tibial plateau: the greater it is, the greater the load the graft experiences [19]. Excessive slope of the plateau can be an anatomical feature of a person or have an acquired character, when in the case of HTVO the "open wedge" is formed more due to the anterior tibia [8]. In our study, tibial osteotomy in patients of group 1 did not lead to significant changes in the inclination of the tibial plateau. Thus, the feasibility of HTVO should also be assessed during revision reconstruction of the ACL against the background of a large posterior inclination of the tibial plateau (≥12º).

At the same time, HTVO leads to redistribution of the load on the lateral parts of the joint, therefore, in patients with injuries of the external meniscus or articular surfaces of the outer part of the knee joint, with valgus deviation of the leg, in case of incompetence of the posterior-external capsular-ligamentous complex of the knee joint, it is inappropriate to perform HTVO simultaneously with rACL.

The increase in the time of surgical intervention in the 1st group is associated with additional stages of the operation. Despite a slight increase in economic costs (time to perform the operation, consumables and medicines) compared to the 2nd group, in the first 5 years after the operation, a much larger number of patients were able to fully return to their work, household and sports activities ($p < 0.05$).

CONCLUSION

1. Simultaneous reconstruction of the anterior cruciate ligament and high valgus osteotomy of the tibia allows to achieve good anatomical and functional results in the treatment of injuries of the anterior cruciate ligament against the background of gonarthrosis, including correction of the limb axis, reduction of pain and synovitis in the knee joint, as in the nearest (93%) and in the late postoperative period in most (88.4%) patients.

2. "Anatomical" plastics of the anterior cruciate ligament should be supplemented with high valgus osteotomy of the tibia in young and middle-aged patients who lead an active lifestyle, including athletes who, along with anterior instability of the knee joint, have signs of varus gonarthrosis or have prerequisites for its development (terms from the moment of damage to the anterior cruciate ligament more than 12 months, varus deviation of the lower leg by more than 5°, absence or destruction of the internal meniscus, areas of chondromalacia or post-traumatic cartilage damage), as well as during revision reconstruction of the anterior cruciate ligament, especially against the background of the posterior slope of the plateau tibia by more than 12º.

3. Performing a high valgus osteotomy of the tibia simultaneously with reconstruction of the anterior cruciate ligament is inappropriate for patients with injuries of the external meniscus or articular surfaces of the external part of the knee joint, with valgus deviation of the leg, failure of the posterior-external capsule-ligamentous complex of the knee joint.

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