Цель. Оценка параартикулярных тканей и венозного оттока по данным ультразвукового дуплексного сканирования (УЗДС) после проведения артроскопической пластики передней крестообразной связки (ПКС). Материалы и методы. Анализ результатов обследования 32 больных с повреждением ПКС в возрасте от 18 до 50 лет (средний возраст 32,62±1,1 лет). Применена технология транстибиальной артроскопической реконструкции ПКС с использованием систем фиксации RigidFix и Biointrafix. УЗДС вен, параоссальных и параартикулярных тканей выполнено на аппарате «HITACHI» HI Vision Avius. Результаты. Проведенные исследования позволили выявить группу больных (удельный вес таких пациентов 12%), у которых к моменту выписки на амбулаторный режим регистрировались гемодинамические признаки дисфункции клапанов глубоких вен голени. По данным сонографии у них сохранялись увеличенными объемы верхнего и бокового заворотов, отек тканей и гематомы по передней медиальной и задней медиальной поверхности голени. Учитывая, что данные изменения носили временный характер и отсутствовали при контрольном осмотре через 1,5 месяца, считаем, что они обусловлены повышенной травматизацией m. semitendinosus и m. gracilis из-за анатомических особенностей строения сухожильно-мышечного комплекса «гусиной лапки» у конкретных пациентов. Заключение: Методика УЗДС вен и параартикулярных тканей после операции артроскопической реконструкции ПКС позволяет выявить группу риска больных по увеличению длительности периода реабилитации. Дисфункция клапанов глубоких вен голени, наличие гематом в стадии фиброзации требуют проведения дополнительных реабилитационных мероприятий, включающих медикаментозное лечение, физиотерапию и лечебную физкультуру с проведением контрольных УЗДС.

Ключевые слова: артроскопическая пластика передней крестообразной связки, ультразвуковое исследование вен и параартикулярных тканей.

DUPLEX SCANNING OF VEINS OF THE LOWER LIMBS AND OF PARAARTICULAR TISSUES AFTER ARTHROSCOPIC RECONSTRUCTION OF THE ANTERIOR CRUCIATE LIGAMENT


Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia

Aim. Evaluation of paraarticular tissues and of venous outflow by the data of ultrasound duplex scanning (USDS) after arthroscopic plasty of the anterior cruciate ligament (ACL). Materials and Methods. Analysis of the results of examination of 32 patients with ACL injury at the age of
18-50 (mean age 32.62±1.1 years). The technology of transtibial arthroscopic reconstruction of ACL was applied with use of RigidFix and Biointrafix systems of fixation. USDS of veins, parossesous and paraarticular tissues was performed using «HITACHI» HI Vision Avius device.

Results. The performed studies permitted to reveal a group of patients (with the share of 12%) in whom, by the moment of discharge from hospital to the outpatient treatment, hemodynamic signs of dysfunction of the valves of deep leg veins were recorded. According to sonography data, the volumes of the upper and lower torsions remained increased, and tissue edema and hematomas along the anteromedial and posteromedial surfaces of the leg persisted. Taking into account the temporary character of these changes with their absence on the follow-up examination after 1.5 months, we think, they were associated with increased traumatization of m. Semitendinosus and m. Gracili due to the anatomical peculiarities of the structure of tendinous-muscular complex (pes anserinum) in certain patients. Conclusions. The technique of USDS of vein and paraarticular tissue after arthroscopic reconstruction of ACL permits to identify a group of patients at risk for prolongation of rehabilitation period. The dysfunctions of the valves of the deep veins of legs, the presence of hematomas at the stage of fibrotization require additional rehabilitation measures including medicinal treatment, physical therapy and exercise therapy under control of USDS.

Keywords: arthroscopic plasty of the anterior cruciate ligament, ultrasound examination of veins and paraarticular tissues.

At present the method of arthroscopy is the «golden standard» of diagnosis and treatment of patients with orthopedic and rheumatologic disorders, in particular, of reconstruction of the anterior cruciate ligament (ACL) in case of its injury. Despite the fact that the method is well developed and minimally invasive, the duration of hospital treatment after this surgery lasts from 3 to 5 days, and duration of rehabilitation period is individual for each patient [1] and is largely determined by the hemodynamics of the limb and by structural condition of soft tissues after the alteration [2,3]. One of symptoms in patients with injury to ACL of the knee joint is instability and aching pain in the area of the knee joint associated both with the impairment of venous drainage and with the condition of the intraosseous circulation in combination with inflammatory changes of the paraarticular soft tissues. A pathogenetic factor of a high risk for development of venous thrombosis in planned orthopedic surgeries on joints is the background venous pathology in the form of low tone of the major veins and dilatation of perforating veins [4].

According to literature data, in 33.9% of cases a role in development of posttraumatic gonarthrosis [5] is played by vascular pathology, with concomitant combinations of disorders in the venous and arterial circulation of the low limbs [6,7]; with this, the occurrence of previously undiagnosed chronic venous insufficiency is 48.8% [8].

Aim of study: evaluation of the condition of paraarticular tissues and venous hemodynamics after arthroscopic plasty of ACL.

Materials and Methods

Results of examination of 32 patients with injury of ACL aged from 18 to 50 years (the average age 32.62±1.11 years) were analyzed.

Ultrasound duplex scanning (USDS) of veins and parossesous tissues was carried out on HITACHI HI Vision Avius device (Japan). According to the currently accepted method, a multi-frequency linear sensor with 5-12 Hz frequency was used in B-mode with color flow and energy Doppler mapping and Doppler spectral analysis of the blood flow in vessels. The study was conducted in 3-4 days after arthroscopic reconstruction of ACL and control examination was conducted in 1.5-2 months. Vascularization and structural condition of paraarticular tissues on the operated and opposite sides were evaluated. Quantitative evaluation of the studied region was per-
formed with a standard setting of the ultrasound apparatus: sonogeometric dimensions were measured using mobile markers, acoustic density (AD, conventional units) was determined using standard computer programs, and peculiarities of vascularization of tissues were identified using color flow mapping (CFM). Qualitative evaluation of soft tissues consisted in determination of the sharpness of contours, existence of characteristic striation and of intermuscular septum.

In all patients the technology of transtibial arthroscopic reconstruction of ACL was carried out using fixating systems RigidFix and Biointrafix [9].

In prehospital stage of study USDS of veins was used to exclude their pathology. In the period of hospital and outpatient treatment not a single case of thrombosis of deep veins of lower limbs was recorded in any of clinical observations. All patients were given prophylaxis of thromboses according to the protocol of patients’ management developed for prophylaxis of thromboembolism of the pulmonary artery in surgical interventions – an adapted variant of a branch standard (State Standards 91500.11. 0007-2003) approved by Order of Health Ministry of RF №233 of 09 Jun 2003.

Statistical processing of the data was carried out using a package of data analysis Microsoft Excel-2000 and Atte Stat. Test of distribution of asymmetry profiles of USDS parameters in the group with the number of observation n=32 using modified Kolmogorov’s and Smirnov’s criteria, and kurtosis and asymmetry criteria showed deviation of hypothesis of normality, that is, the studied parameters did not follow the «normal distribution law». Quantitative characteristics of sample population are presented in a table in the form of median with the level 25%÷75% of percentiles and the number of observations corresponding to the number of studied individuals. The results of studies were processed with variation statistics methods used for small sample with the level of significance assumed to be p<0.05. Statistical significance of differences was determined using Wilcoxon test.

The study was conducted with the permission of the Ethics Committee of Ilizarov Scientific Center Restorative Traumatology and Orthopaedics. All participants signed informed consent for conduction of the study and publication of the results without identification of personality.

Results and Discussion

In 3-4 days after the arthroscopic plasty of ACL, all patients had increased thickness of the superior and lateral recesses, hematomas along the anterior surface of the shin in the area of pes anserinus, hypervascularization with signs of vasodilatation. The popliteal region had local disorders in the characteristic muscle striation and echo signs of hematomas formed after taking graft. According to USDS, in 3-4 days after the arthroscopic plasty of ACL, the external iliac vein, superficial, deep femoral, popliteal veins were passable throughout the whole length available for study. Blood flow through them was phasic, associated with breathing. The walls of the veins were not thickened, no additional masses were found in their lumen. In functional tests with proximal and distal digital compression in all patients a reduction in the increment of linear blood flow velocity was recorded through the common femoral vein, in distal digital compression of the hip and shin less than 100%, which is associated with permanent wearing of elastic stockings in the postoperative period as an obligatory measure of prophylaxis of thromboembolism of the pulmonary artery (TEPA).

No hemodynamic signs of disorders in the venous patency were found in all the examined patients, but in a part of patients USDS revealed hemodynamic signs of dysfunction of the valves of deep shin veins of the reflux-type disorder in the evacuating function of the muscle-venous pump of the operated limb [10].

On the basis of the results of USDS of veins and pararosseous tissues patients were divided into two groups:

I group – 22 patients in whom compression manual tests revealed no dysfunction of the valves of deep shin veins.
II group – 10 patients in whom USDS revealed dysfunction of the valves of the deep vein of shin: reduction in the venous outflow velocity though popliteal vein, absence of increment in linear blood flow velocity (LBFV) in manual proximal compression of the popliteal vein, retrograde blood flow up to 0.5 sec [10]. In all patients of II group an autograft was taken during surgery with the necessarily more extensive traumatization of *m. semitendinosus* and *m. gracilis* because of the anatomical peculiarities of the tendon-muscle complex of *pes anserinus* – with additional taking of the tendon of *m. gracilis* due to insufficient thickness of the tendon of *m. semitendinosus* [11].

Results of USDS of veins are given in Table 1.

**Table 1**

*Ultrasound Dopplerography of Veins of Lower Limb in Patients after Arthroscopic Reconstruction of ACL*

<table>
<thead>
<tr>
<th></th>
<th>I group (n=22)</th>
<th></th>
<th>II group (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large subcutaneous femoral vein</td>
<td>Large subcutaneous vein</td>
<td>Small subcutaneous vein</td>
</tr>
<tr>
<td></td>
<td>Vm, cm/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.6 (8.4÷20.6)</td>
<td>4.0 (3.0÷4.7)</td>
<td>2.9 (2.5÷3.0)</td>
</tr>
<tr>
<td></td>
<td><strong>Common femoral vein</strong></td>
<td><strong>Popliteal vein</strong></td>
<td><strong>Posterior tibial vein</strong></td>
</tr>
<tr>
<td></td>
<td>Vm, cm/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.1 (9.2÷17.4)</td>
<td>14.9 (8.0÷21.2)</td>
<td>4.5 (4.0÷5.1)</td>
</tr>
<tr>
<td><strong>Distal compression</strong></td>
<td>(increase in LBFV, %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of hip</td>
<td>82.6 (52.4÷112.5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>of shin</td>
<td>46.8 (32.1÷64.9)</td>
<td>190.3 (115.0÷250.9)</td>
<td>-</td>
</tr>
<tr>
<td>of foot</td>
<td>-</td>
<td>-</td>
<td>487.5 (267.0÷892.0)</td>
</tr>
<tr>
<td><strong>Proximal compression</strong></td>
<td>(increase in LBFV, %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>94.6 (64.6÷130.4)</td>
<td>106.2 (66.8÷148.1)</td>
<td>468.5 ± (215.0÷732.0)</td>
</tr>
<tr>
<td></td>
<td><strong>Large subcutaneous femoral vein</strong></td>
<td><strong>Large subcutaneous vein</strong></td>
<td><strong>Small subcutaneous vein</strong></td>
</tr>
<tr>
<td></td>
<td>Vm, cm/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.8 (6.9÷15.3)</td>
<td>4.8 (3.1÷5.8)</td>
<td>3.5 (2.5÷4.9)</td>
</tr>
<tr>
<td></td>
<td><strong>Common femoral vein</strong></td>
<td><strong>Popliteal vein</strong></td>
<td><strong>Posterior tibial vein</strong></td>
</tr>
<tr>
<td></td>
<td>Vm, cm/sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13.2 (7.4÷19.8)</td>
<td>4.7* (3.0÷6.3)</td>
<td>4.0 (3.7÷4.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* p = 0.0115</td>
<td></td>
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<tr>
<td><strong>Distal compression</strong></td>
<td>(increase in LBFV, %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of hip</td>
<td>18.3* (12.5÷44.8)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* p = 0.0089</td>
<td></td>
</tr>
<tr>
<td>of shin</td>
<td>73.9 (45.6÷82.1)</td>
<td>111.0 (81.9÷194.0)</td>
<td>-</td>
</tr>
<tr>
<td>of foot</td>
<td>-</td>
<td>-</td>
<td>595.3 (254.0÷912.0)</td>
</tr>
<tr>
<td><strong>Proximal compression</strong></td>
<td>(increase in LBFV, %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51.0* (34.6÷63.5)</td>
<td>-20.4* (40.3÷10.6)</td>
<td>425.7 (205.0÷811.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* p = 0.0412</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* p = 0.0009</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** Vm – maximal linear velocity in spectrum, median (25%÷75%); n – number of observations; * – statistical significance of differences, Wilcoxon test relative to I group.

In all patients in 10-14 days after the arthroscopic reconstruction of ACL, ultrasound scanning visualized enlargement of the superior and lateral recess with hypoecho-
dence in patients of I and II groups was different. In patients of II group the superior and lateral recess were 3 times and 4.5 times enlarged in volume, respectively, and edema of tissues and hematomas along the anteromedial and posteromedial surface of shin were more pronounced.

On a repeated examination before discharge from hospital (on the 10th-14th day after surgery) hematomas in all patients were not visualized, the volume of recess in patients of I group decreased 2-3 times, and insignificantly decreased in patients of II group.

On the basis of USDS data, by the 14th day after surgery hemodynamic signs of dysfunction of the deep shin veins persisted in 4 patients of II group. Manual tests with proximal and distal compression revealed bidirectional «pendulum-like» signal in deep shin veins (flashes of yellow light filling the lumen of vessel) that permitted to diagnose segmental varicose transformation with reflux through perforating veins (Fig. 1).

Clinically, edema of the shin and of the knee joint persisted. On the anteromedial surface of the upper third of the shin, knee joint and the lower third of hip, ecchymosis was seen. The knee joint remained locally painful to palpation.

Ultrasound and USDS data of control examination in 1.5 months did not reveal significant changes, the results of compression manual tests corresponded to norms. Patients of I group were on the sick list for 14 to 30 days, and those of II group – for 25-50 days.

A clinical example may be sonograms of patient L., 29 years old. The diagnosis: injury of the anterior cruciate ligament of the right knee. Condition after reconstructive arthroscopy of ACL. In 3 days after arthroscopic reconstruction of ACL, USDS showed dilation of the popliteal vein on the right to 1.2 cm, it was patent along the available length and was easily compressible by the sensor. Velocity of venous outflow was reduced to 4.5 cm/sec. In the functional test with maximal manual compression of the popliteal vein, no increase in linear velocity of blood was found, and retrograde blood flow was recorded with duration up to 0.5 sec. Sural veins were dilated to 0.3 cm. In changing to vertical position the lumen of popliteal vein increased to 1.7 cm.

Fig. 1. Sonogram of deep shin vein, USDS. Performed with distal compression test. Retrograde blood flow is recorded
Figure 2 shows a sonogram of the medial part of knee joint in the frontal plane in 2 days after arthroscopic reconstruction of ACL. In longitudinal scanning, thickening and edema of synovium were determined in the projection of the lateral subligamentous space of the knee joint. Doppler scanning showed a local hypervascularization of the studied zone, the mean linear blood flow velocity (Vm) made 54.6% of the peak linear velocity (Vp), which was interpreted as evident vasodilatation of vessels.

In sonograms of the popliteal region, echo signs of edema and of local disorders in the characteristic striation of *m. gastrocnemius*, hematomas of irregular shape with echo signs of fibrotization were visualized. Scanning in 1.5 months after the operation visualized residual fluid in the region of the superior and lateral recesses and single vessels in the surrounding soft tissues with spectral and velocity characteristics corresponding to the contralateral level. No echo signs of hematomas were identified. Structure of *m. gastrocnemius* in the region of alteration completely recovered and did not differ from the contralateral shin.

Ultrasound of patients of the second group with enhanced traumatization of *m. semitendinosus* and *m. gracilis* due to anatomical peculiarities of the tendon-muscle complex of *pes anserinus*, in 10-14 days after arthroscopic reconstruction of ACL showed 3-fold enlarged superior recess and 4.5-fold enlarged lateral recess, pronounced edema of tissues and hematomas up to 52.9x10x13 mm in size along the anteromedial and posteromedial surface of the shin. In orthostasis with limited axial load on the limb and with limited movements in the knee joint in the operated limb, a drop of the blood pressure in deep veins occurred, and with the absence of shin contraction, the function of muscle-venous pump was frustrated [13]. Traumatization of tissues was accompanied by enhanced arterial inflow with local dilatation of vessels and evident hypervascularization.

The obtained results of US examination of soft tissues and of USDS of veins after arthroscopic reconstruction of ACL agree with the data of other authors: frustration of a complicated interaction between muscular and venous components of the so called muscular-venous pump of the shin leading to ectasia of veins and to reduction in blood velocity in them [14]. Trauma was associated with regional venous hypervolemia in tissues which developed segmentally in a part of venous circulation due to loss of normal elastic properties of the venous wall with gradual...
Taking into account the fact that these changes were temporary and were absent on control examination in 1.5 months we think they were due to enhanced traumatization of *m. semitendinosus* and *m. gracilis* because of the anatomical peculiarities of the tendinous-muscular apparatus of *pes anserinus* in particular patients. This must be taken into consideration in the out-patient management of such patients with probable prolongation of rehabilitation period including medicinal treatment, physiotherapy and exercise therapy with additional control ultrasound examinations.

**Conclusion**

Method of ultrasound duplex scanning of veins and paraarticular tissues after arthroscopic reconstruction of the anterior cruciate ligament permits to identify a group of patients at risk of prolongation of the rehabilitation period. Record of hemodynamic signs of dysfunction of the valves of deep shin veins, existence of hematomas in the fibrotization stage on the 10th day after operation may be considered as an additional criterion for additional rehabilitation measures including medicinal treatment, physiotherapy and exercise therapy with control ultrasound duplex scanning.

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