DOI:10.23888/PAVLOVJ2018263407-416

ДУПЛЕКСНОЕ СКАНИРОВАНИЕ ВЕН НИЖНЕЙ КОНЕЧНОСТИ И ПАРААРТИКУЛЯРНЫХ ТКАНЕЙ ПОСЛЕ АРТРОСКОПИЧЕСКОЙ РЕКОНСТРУКЦИИ ПЕРЕДНЕЙ КРЕСТООБРАЗНОЙ СВЯЗКИ

© Т.И. Долганов, Т.И. Менщикова, Т.Ю. Карасева, Д.В. Долганов, И.Н. Менщиков, А.Г. Карасев

ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия

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 поверхностям 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. gracili* 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. Дисфункции клапанов глубоких вен голени, наличие гематом в стадии фибротизации 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

T.I. Dolganova, T.I. Menshchikova, T.Iu. Karaseva, D.V. Dolganov, I.N. Menshchikov, A.G. Karasev

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

DOI:10.23888/PAVLOVJ2018263407-416

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, paraosseous 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 deepleg veins were recorded. According to sonography data, the volumes of the upper and lateral 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 withtheir absenceon 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 reconstructionof ACL permits to identify a group of patients at risk for prolongation of rehabilitation period. The dysfunctions of the valves of the deep veinsof 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 paraosseous 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-

DOI:10.23888/PAVLOVJ2018263407-416

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 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 paraosseous 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.

DOI:10.23888/PAVLOVJ2018263407-416

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

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

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 hypoechogenic structure, single hematomas with no sharp contour along the anteromedial and posteromedial surface of shin, and edema of subcutaneous tissue. The extent of their evi-

DOI:10.23888/PAVLOVJ2018263407-416

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 10^{th}-14^{th} 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 14^{th} 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).

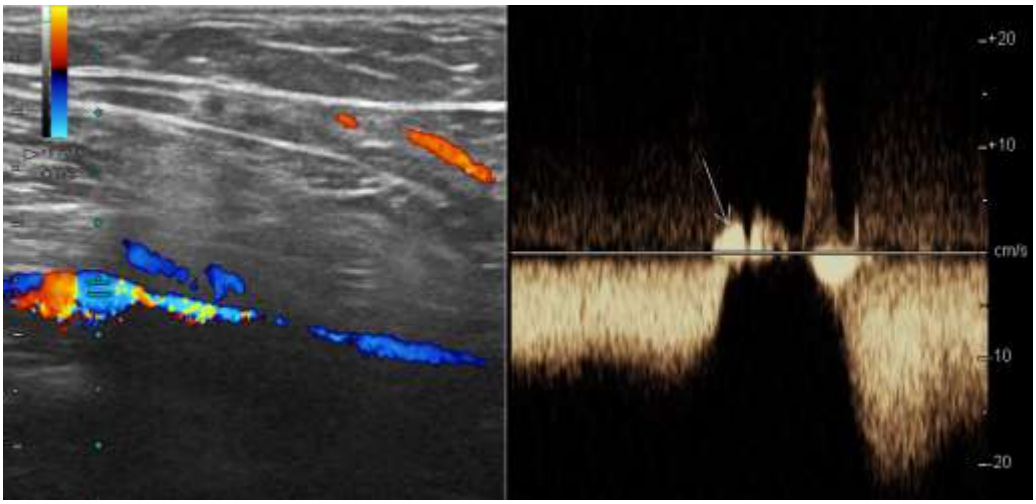

Fig. 1. Sonogram of deep shin vein, USDS. Performed with distal compression test. Retrograde blood flow is recorded

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. Four patients were on the sick list for 90 days (three months required for ingrowth of the graft into the knee joint [12]), and by the moment of discharge from hospital hemodynamic signs of dysfunction of the valves of the deep shin veins in them persisted.

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.

DOI:10.23888/PAVLOVJ2018263407-416

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.

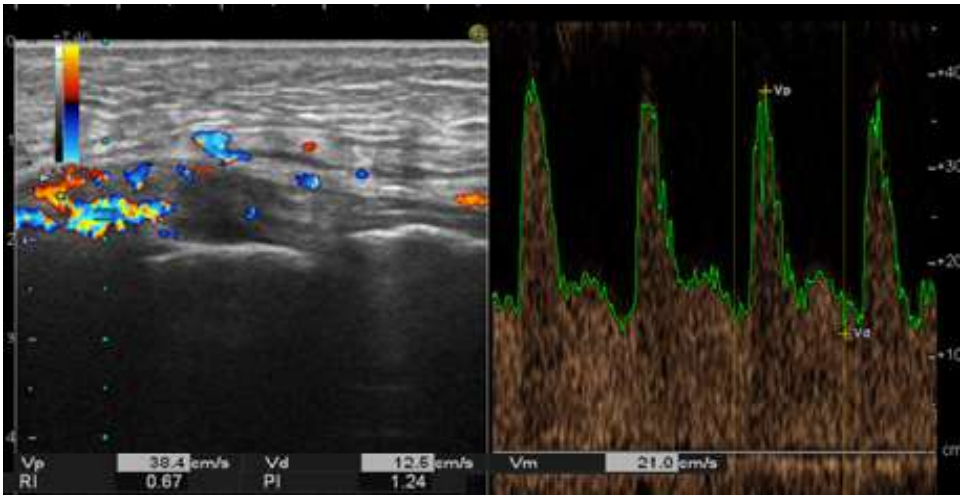

Fig. 2. Sonogram of medial surface of the knee joint of patient L., 29 years old (triplex scanning mode is used)

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

DOI:10.23888/PAVLOVJ2018263407-416

local ectasia of the vessel and development of valvular insufficiency [15]. The cause of developing disorders was not elevated pressure in different segments of the vein, but a reduced vessel tone resulting from a constant influence of motor and sensory inputs [16]. With the absence of «muscle systole» (active contraction of shin muscles) this leads to stasis of blood in small venules and capillaries and to retardation of filtration of fluid and products of catabolism from extravasal space to venous vessels [17].

The conducted studies permitted to identify a group of patients – 4 individuals (12%) of 32 examined people in whom by the moment of discharge from hospital for follow-up treatment, hemodynamic signs of dysfunction of the valves of deep shin veins were recorded. According to sonography data, they preserved enlarged volumes of the superior and lateral recesses, edema of tissues and hematomas along the anteromedial and posteromedial shin surfaces. In planning of the volume of surgery and a probable extent of traumatization of tissues in taking the tendon-muscular complex of *pes anserinus* it is reasonable to carry out magnetic resonance imaging assessment of its anatomical peculiarities.

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 10^{th} 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.

Литература

1. Долганова Т.И., Сизова Т.В., Карасев Е.А., и др. Функциональное состояние нижних конечностей у больных с внутрисуставными переломами коленного сустава после лечения аппаратом Илизарова в сочетании с артроскопией // Российский медико-биологический вестник имени академика И.П. Павлова. 2013. Т. 21, №2. С. 124-129.
2. Myer G.D., Paterno M.V., Ford K.R., et al. Neuromuscular training techniques to target deficits before return to sport after anterior cruciate ligament reconstruction // J. Strength Cond. Res. 2008. Vol. 22, №3. P. 987-1014. doi:10.1519/JSC.0b013e31816a86cd
3. Kester B.S., Behery O.A., Minhas S.V., et al. Athletic performance and career longevity following anterior cruciate ligament reconstruction in the National Basketball Association // Knee Surg. Sports Traumatol. Arthrosc. Vol. 25, №10. P. 3031-3037. doi:10.1007/s00167-016-4060-y
4. Копенкин С.С. Профилактика венозных тромбоэмболических осложнений в ортопедической хирургии: новые возможности // Вестник травматологии и ортопедии им. Н.Н. Приорова. 2010. №1. С. 35-38.
5. Чегуров О.К., Макушин В.Д. Оперативное лечение посттравматического гонартроза // Гений ортопедии. 2011. №2. С. 60-64.
6. Долганова Т.И., Сазонова Н.В. Оценка периферической гемодинамики у больных с остеоартрозом коленного сустава II стадии // Фундаментальные исследования. 2009. №4. С. 29-31.
7. Долганова Т.И., Чегуров О.К., Карасева Т.Ю., и др. Оценка периферической гемодинамики у больных с гонартрозом II-III стадии при лечении методикой корригирующей остеотомии в сочетании с артроскопией // Регионарное кровообращение и микроциркуляция. 2011. Vol. 10, №3. С. 38-43.
8. Щеглов А.Щ. Хроническая венозная недостаточность и гонартроз // Вестник травматологии и ортопедии им. Н.Н. Приорова. 2012. №2. С. 31-34.

DOI:10.23888/PAVLOVJ2018263407-416

9. Карасева Т.Ю., Карасев Е.А. Артроскопические технологии лечения больных с нестабильностью коленного сустава // Гений ортопедии. 2013. №4. С. 38-43.
10. Гришин И.Н., Подгайский В.Н., Старосветская И.С. Варикоз и варикозная болезнь нижних конечностей. Минск: Вышейшая школа; 2005.
11. Кузнецов И.А., Рыбин А.В. Анатомические варианты строения сухожилия полусухожильной мышцы-трансплантата, используемого при артроскопической аутопластике передней крестообразной связки коленного сустава // Травматология и ортопедия России. 2006. №1. С. 27-29.
12. Тихилов Р.М., Трачук А.П., Богопольский О.Е., и др. Восстановительное лечение после реконструкции передней крестообразной связки коленного сустава. Руководство для пациента. СПб; 2009.
13. Лукьянов В.В., Бондаренко А.В., Бондаренко А.А., и др. Нарушения венозной гемодинамики и тромболические осложнения при остеосинтезе переломов нижних конечностей // Политравма. 2009. №4. С. 32-38.
14. Зубарев А.Р., Градусов Е.Г., Кривошеева Н.В. Диагностические возможности ультразвукового ангиосканирования в оценке патологического дренажа вен голени у больных варикозной болезнью // Медицинская визуализация. 2006. №6. С. 113-117.
15. Лазаренок В.А, Санников А.Б., Шевелев Е.Л. Сегментарная венозная гиперволемия как один из основных патогемодинамических факторов развития и прогрессирования хронической венозной недостаточности нижних конечностей у пациентов с варикозной болезнью // Вестник хирургии. 2003. №5. С. 19-25.
16. Константинова Г.Д., Зубарев А.Р., Градусов Е.Г. Флебология. М.: Издательский дом Видар; 2000.
17. Сушков С.А. Недостаточность клапанов глубоких вен при варикозной болезни (эпидемиология, этиология, патогенез, диагностика) // Новости хирургии. 2010. Т. 18, №4. С. 119-134.

References

1. Dolganova TI, Sizova TV, Karasev EA, et al. Funktsional'noe sostoianie nizhnikh konechnostei u bol'nykh s vnutrisustavnymi perelomami kolennogo sustava posle lecheniia apparatom Ilizarova v sochetanii s artroskopiei. *IP Pavlov Russian Medical Biological Herald.* 2013:21(2):124-9. (In Russ).
2. Myer GD, Paterno MV, Ford KR, et al. Neuromuscular training techniques to target deficits before return to sport after anterior cruciate ligament reconstruction. *J Strength Cond Res.* 2008;22(3): 987-1014. doi:10.1519/JSC.0b013e31816a86cd
3. Kester BS, Behery OA, Minhas SV, et al. Athletic performance and career longevity following anterior cruciate ligament reconstruction in the National Basketball Association. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(10):3031-7. doi:10.1007/s00167-016-4060-y
4. Kopenkin SS. Profilaktika venoznykh tromboembolicheskikh oslozhnenii v ortopedicheskoi khirurgii: novye vozmozhnosti. *Vestnik travmatologii i ortopedii im. NN Priorova.* 2010;(1):35-8. (In Russ).
5. Chegurov OK, Makushin VD. Operativnoe lechenie posttravmaticheskogo gonartroza. *Genii Ortopedii.* 2011;2:60-4. (In Russ).
6. Dolganova TI, Sazonova NV. Otsenka perifericheskoi gemodinamiki u bol'nykh s osteoartrozom kolennogo sustava II stadii. *Fundamental'nye issledovaniia.* 2009;4:29-31. (In Russ).
7. Dolganova TI, Chegurov OK, Karaseva TIu, et al. Otsenka perifericheskoi gemodinamiki u bol'nykh s gonartrozom II-III stadii pri lechenii metodikoi korrigiruiushchei osteotomii v sochetanii s artroskopiei. *Regionarnoe krovoobrashchenie i mikrotsirkuliatsiia.* 2011;10(3):38-43. (In Russ).
8. Shcheglov AShch. Khronicheskaia venoznaia nedostatochnost' i gonartroz. *Vestnik travmatologii i ortopedii im. NN. Priorova.* 2012;(2):31-4. (In Russ).
9. Karaseva TIu, Karasev EA. Artroskopicheskie tekhnologii lecheniia bol'nykh s nestabil'nost'iu kolennogo sustava. *Genii Ortopedii.* 2013;4:38-43. (In Russ).
10. Grishin IN, Podgaiskii VN, Starosvetskaia IS. *Varikoz i varikoznaia bolezn' nizhnikh konechnostei.* Minsk: Vysheyshaya shkola; 2005. (In Russ).
11. Kuznetsov IA, Rybin AB. Anatomicheskie varianty stroeniia sukhozhiliia polusukhozhil'noi myshtsy-transplantata, ispol'zuemogo pri artroskopicheskoi autoplastike perednei krestoobraznoi sviazki kolennogo sustava. *Travmatologiia i Ortopediia Rossii.* 2006;1:27-9. (In Russ).
12. Tikhilov RM, Trachuk AP, Bogopol'skii OE, et al. Vosstanovitel'noe lechenie posle rekonstruktsii perednei krestoobraznoi sviazki kolennogo sustava. Rukovodstvo dlia patsienta. Sankt-Peterburg; 2009. (In Russ).
13. Luk'ianov VV, Bondarenko AV, Bondarenko AA, et al. Narusheniia venoznoi gemodinamiki i trombolicheskie oslozhneniia pri osteosinteze perelomov nizhnikh konechnostei. *Politravma.* 2009; 4:32-8. (In Russ).
14. Zubarev AR, Gradusov EG, Krivosheeva NV. Diagnosticheskie vozmozhnosti ul'trazvukovogo angioskanirovaniia v otsenke patologicheskogo drenazha ven goleni u bol'nykh varikoznoi bolezn'iu. *Meditsinskaia vizualizatsiia.* 2006;6:113-7. (In Russ).
15. Lazarenok VA, Sannikov AB, Shevelev EL. Segmentarnaia venoznaia gipervolemiia kak odin iz osnovnykh patognodinamicheskikh faktorov razvi-

DOI:10.23888/PAVLOVJ2018263407-416

tiia i progressirovaniia khronicheskoi venoznoi nedostatochnosti nizhnikh konechnostei u patsientov s varikoznoi bolezn'iu. Vestnik khirurgii. 2003; 5:19-25. (In Russ).
16. Konstantinova GD, Zubarev AR, Gradusov EG. *Flebologiia*. Moscow: Izdatel'skii dom Vidar; 2000. (In Russ).
17. Sushkov SA. Nedostatochnost' klapanov glubokikh ven pri varikoznoi bolezni (epidemiologiia, etiologiia, patogenez, diagnostika). *Novosti Khirurgii.* 2010;18(4):119-34. (In Russ).

Дополнительная информация [Additional Info]

Финансирование исследования. Бюджет ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России. [**Financing of study**. Budget of Ilizarov Scientific Center Restorative Traumatology and Orthopaedics.]

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, о которых необходимо сообщить в связи с публикацией данной статьи. [**Conflict of interests**. The authors declare no actual and potential conflict of interests which should be stated in connection with publication of the article.]

Участие авторов. Долганов Т.И. – концепция и дизайн исследования, выполнение УЗДС, Менщикова Т.И. – выполнение УЗИ, написание текста, редактирование, Карасева Т.Ю. – выполнение артроскопии, Д.В. Долганов – статистическая обработка материала, Менщиков И.Н. – выполнение артроскопии, сбор и клиническая обработка материала, Карасев А.Г. – сбор и обработка материала. [**Participation of authors.** T.I. Dolganova – concept and design of the study, ultrasound duplex scanning, T.I. Menshchikova – ultrasound duplex scanning, writing the text, editing, T.Iu. Karaseva – arthroscopic plasty, D.V. Dolganov – statistical processing, I.N. Menshchikov – arthroscopic plasty, acquisition and clinical processing of the material, A.G. Karasev – acquisition and processing of the material.]

Информация об авторах [Authors Info]

*__Долганова Тамара Игоревна –__ д.м.н., ведущий научный сотрудник лаборатории коррекции деформации и удлинения конечностей ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. [**Tamara I. Dolganova** – MD, PhD, Leading Researcher of Scientific and Clinical Laboratory for Deformity Correction and Lengthening of Limbs, Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 9221-3900, ORCID ID: 0000-0002-0117-3451, Researcher ID: B-8897-2018. E-mail: rjik532007@rambler.ru

Менщикова Татьяна Ивановна – д.биол.н., ведущий научный сотрудник лаборатории коррекции деформации и удлинения конечностей ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. [**Tatyana I. Menshchikova** – MD, PhD in Biological sciences, Leading Researcher of Scientific and Clinical Laboratory for Deformity Correction and Lengthening of Limbs, Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 2820-9120, ORCID ID: 0000-0002-5244-7539, Researcher ID: C-4470-2018.

Карасева Татьяна Юрьевна – к.м.н., врач травматолого-ортопедического отделения №3 ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. [**Tatyana Iu. Karaseva** – MD, PhD, Doctor of Traumatologic and Orthopedic Department №3 Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 1586-5004, ORCID ID: 0000-0002-7708-7808, Researcher ID: C-8620-2018.

Долганов Дмитрий Владимирович – к.биол.н., старший научный сотрудник лаборатории лаборатория коррекции деформации и удлинения конечностей ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. [**Dmitriy V. Dolganov** – MD, PhD in Biological sciences, Senior Researcher of Scientific and Clinical Laboratory for Deformity Correction and Lengthening of Limbs, Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 6714-6049, ORCID ID: 0000-0002-8708-1303, Researcher ID: B-9578-2018.

Менщиков Илья Николаевич – аспирант ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. [**Ilya N. Menshchikov –** PhD Student, Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 8981-9120, ORCID ID: 0000-0002-8382-6355, Researcher ID: C-8484-2018.

Карасев Анатолий Григорьевич – д.м.н., врач травматолого-ортопедического отделение №1 ФБГУ РНЦ Восстановительная травматология и ортопедия им. акад. Г.А. Илизарова Минздрава России, Курган, Россия. **[Anatoliy G. Karasev –** MD, PhD, Doctor of Traumatologic and Orthopedic Department №1, Ilizarov Scientific Center Restorative Traumatology and Orthopaedics, Kurgan, Russia.]
SPIN: 2586-7460, ORCID ID: 0000-0001-6580-6521, Researcher ID: C-8624-2018.

DOI:10.23888/PAVLOVJ2018263407-416

Цитировать: Долганова Т.И., Менщикова Т.И., Карасева Т.Ю., Долганов Д.В., Менщиков И.Н., Карасев А.Г. Дуплексное сканирование вен нижней конечности и параартикулярных тканей после артроскопической реконструкции передней крестообразной связки // Российский медико-биологический вестник имени академика И.П. Павлова. 2018. Т. 26, №3. С. 407-416. doi:10.23888/PAVLOVJ2018263407-416

To cite this article: Dolganova TI, Menshchikova TI, Karaseva TIu, Dolganov DV, Menshchikov IN, Karasev AG. Duplex scanning of veins of the lower limbs and of paraarticular tissues after arthroscopic reconstruction of the anterior cruciate ligament. *IP Pavlov Russian Medical Biological Herald.* 2018; 26(3):407-16. doi:10.23888/PAVLOVJ2018263407-416

Поступила/Received: 18.03.2018
Принята в печать/Accepted: 10.09.2018