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INJURIES AND DAMAGE TO LARGE JOINTS IN UNDERAGE ATHLETES. THERAPY WITH PLATELET-RICH PLASMA. A CLINICAL CASE

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Introduction. Approximately 46% of large joint injuries involve damage to the knee joint, among which anterior cruciate ligament (ACL) injuries account for about 15–24% in children and adolescents. In order to reduce the likelihood of long-term complications after injuries in underage professional athletes, shorten the rehabilitation period, and enable a quicker return to elite sports, innovative regenerative medicine technologies should be implemented into clinical practice, including the use of platelet-rich plasma (PRP). In comparison with other conservative treatment methods, PRP offers several advantages. Being an orthobiological agent, PRP is a biological substance derived from the patient's own body, promoting accelerated regeneration with minimal risk of side effects. When performed correctly, this procedure shows minimal invasiveness and does not lead to complications. Although PRP therapy is widely used in treating diseases and injuries of large joints in adult patients, the application of this therapeutic method in underage athletes has not been sufficiently studied, which is the focus of this study.

Case report. We present a clinical case of a professional athlete with a knee joint injury, assessing the functional and clinical outcomes of PRP therapy. Two standardized methods for PRP application are demonstrated, highlighting the advantages of a closed-loop PRP preparation system. These include minimized exposure to the external environment, mitigating potential risks of infection, and reduced consumption of materials, enhancing cost-effectiveness. The described clinical case of an ACL injury in a junior athlete, with complete functional and structural recovery (as confirmed by magnetic resonance imaging, MRI), demonstrated the efficacy, safety, and good tolerability of PRP therapy. Positive outcomes were observed both clinically (regression of pain assessed via the visual analog scale, restoration of joint function, and positive dynamics in provocative tests such as the Lachman test and anterior drawer test) and through MRI data.

Conclusions. The use of PRP therapy for ACL injuries in underage professional athletes represents a promising therapeutic approach in orthopedics and sports medicine, utilizing regenerative medicine technologies. The closed-loop system for PRP preparation offers several advantages over open-loop systems, including cost-effectiveness due to minimized consumption of medical supplies. The safety of the method is ensured provided that the procedural requirements are met (asepsis, antisepsis, ultrasound guidance, etc.); the high sensitivity of MRI in tracking the dynamics of ACL injuries is confirmed.

Keywords: sports medicine; pediatric sports injuries; large joint damage; PRP therapy; underage athletes

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ТРАВМЫ И ПОВРЕЖДЕНИЯ КРУПНЫХ СУСТАВОВ У НЕСОВЕРШЕННОЛЕТНИХ СПОРТСМЕНОВ. ТЕРАПИЯ ПЛАЗМОЙ, ОБОГАЩЕННОЙ ТРОМБОЦИТАМИ. КЛИНИЧЕСКИЙ СЛУЧАЙ

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Введение. Около 46% травм крупных суставов занимают повреждения коленного сустава, в структуре которых у детей и подростков порядка 15–24% приходится на переднюю крестообразную связку (ПКС). Для сокращения вероятности отдаленных осложнений после травм у несовершеннолетних профессиональных спортсменов, реабилитационного периода и скорейшего возвращения в спорт высших достижений необходимо внедрение в клиническую практику инновационных технологий регенеративной медицины, в том числе с использованием плазмы, обогащенной тромбоцитами (PRP). Применение PRP имеет ряд преимуществ по сравнению с другими консервативными методами терапии, а именно: являясь ортобиологическим препаратом, PRP представляет собой биологическое вещество собственного организма пациента, способствующее ускорению регенерации с минимальным риском возникновения побочных явлений; это малоинвазивная манипуляция, при соблюдении методики не приводящая к осложнениям. Несмотря на то что PRP-терапия широко применяется при лечении заболеваний и повреждений крупных суставов у взрослой

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категории пациентов, использование данного терапевтического метода у несовершеннолетних спортсменов изучено недостаточно, в связи с чем и явилось целью настоящей работы.

Описание клинического случая. Представлено клиническое наблюдение профессионального спортсмена с травмой коленного сустава с оценкой функциональных и клинических результатов PRP-терапии. В данной работе продемонстрированы две стандартизированные методики по применению PRP, обозначены преимущества закрытого цикла приготовления PRP: минимизация контакта с внешней средой, снижающего возможные риски инфицирования; сокращение расходных материалов, повышающего экономическую эффективность. Описанный клинический случай травмы ПКС у юниора с полным функциональным и структурным (по данным магнитно-резонансной томографии) восстановлением при проведении PRP-терапии продемонстрировал эффективность, безопасность и хорошую переносимость применения плазмы, обогащенной тромбоцитами. Положительный результат отмечен как клинически (констатация регресса болевого синдрома, оцениваемого по визуально-аналоговой шкале, восстановления функции сустава, положительная динамика провокационных тестов (тест Лахмана и переднего выдвижного ящика)), так и по данным визуализации.

Выводы. Применение PRP-терапии при травмах ПКС у несовершеннолетних профессиональных спортсменов является перспективным терапевтическим подходом в ортопедии и спортивной медицине с использованием технологий регенеративной медицины. Закрытый цикл приготовления PRP имеет ряд преимуществ перед открытым, включая экономическую эффективность благодаря минимизации расхода медицинских изделий. Показана безопасность метода при соблюдении требований к его проведению (асептика, антисептика, ультразвуковой контроль и др.) и подтверждена высокая чувствительность магнитно-резонансной томографии в рамках оценки динамики повреждений ПКС.

Ключевые слова: спортивная медицина; детские спортивные травмы; повреждения крупных суставов; PRP-терапия; несовершеннолетние спортсмены

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INTRODUCTION

The development of physical culture and sports, including youth sports, is a priority direction of Russian state policy.^{1,2} According to the list of instructions of the President of Russia,³ the Federal Medical-Biological Agency (FMBА) serves as the lead organization for medical support and biomedical supervision of athletes in Russian national teams. This role, combined with the country's strategic national priorities in scientific and technological development, drives the adoption of innovative technologies in sports medicine.⁴

In Russia, approximately 24.3 million children regularly engage in physical culture, with 3.2 million training in sports centers. Elite sports involve about 17,000 children. Sports-related injuries account for about 35.8% of all injuries among children (aged 5–17) [1]. Knee injuries dominate (approximately 46% of all major joint injuries), with anterior cruciate ligament (ACL) injuries remaining

highly prevalent among professional athletes, children, and adolescents. These are severe conditions, comprising 15–24% of such injuries, while meniscus trauma occurs at a rate of 5.1 per 100,000 juniors [2, 3]. Upper limb injuries (shoulder, elbow joints) are common among athletes (including children) involved in overhead activities. In 75% of cases, these injuries result in temporary exclusion from sports [4], yet only 5% require surgical intervention [5].

The development of physical culture and sports in Russia has led to a growing number of professional athletes, increasing the incidence of sports-related injuries. This trend necessitates the adoption of novel therapeutic approaches, including regenerative medicine technologies such as the use of platelet-rich plasma (PRP).

PRP, as an orthobiological agent and a biological substance derived from the patient's own body, accelerates recovery and promotes regeneration, alleviates pain, and shortens the rehabilitation period. This

¹ Decree of the Government of the Russian Federation No. 3081-r dated 24.11.2020 "On the Approval of the Strategy for the Development of Physical Culture and Sports in the Russian Federation for the Period up to 2030". URL: <https://docs.cntd.ru/document/566430492>

² Resolution of the Government of the Russian Federation No. 1661 dated 30.09.2021 "On the Approval of the State Program of the Russian Federation 'Development of Physical Culture and Sports'". URL: <https://base.garant.ru/402891691/>

³ List of Instructions of the President of the Russian Federation following the meeting of the Presidential Council for the Development of Physical Culture and Sport dated 29.11.2024, No. Pr-2500. URL: <http://www.kremlin.ru/acts/assignments/orders/75738>

⁴ Decree of the President of the Russian Federation No. 145 dated 28.02.2024, "On the Strategy for Scientific and Technological Development of the Russian Federation". URL: <http://www.kremlin.ru/acts/bank/50358>

is particularly critical in elite sports [6, 7]. Moreover, when performed according to guidelines, PRP therapy is a minimally invasive technique with a low complication rate [8]. While numerous publications address the use of PRP for joint diseases in adults with osteoarthritis and in older professional athletes [9, 10], studies evaluating the efficacy of PRP in underage athletes with injuries to large joints remain insufficient.

This work presents a clinical case of a professional athlete with a knee joint injury, assessing the functional and clinical outcomes of PRP therapy.

Preparation of Platelet-Rich Plasma (PRP)

Injuries and damage to various segments of the limbs are an unfortunate but integral part of elite sports. PRP has been successfully applied in such conditions as tennis elbow, golfers elbow, Achilles tendon injuries and plantar fasciitis, rotator cuff syndrome, adductor enthesopathy, jumpers knee, and runners knee [11].

PRP is human blood plasma with a concentration of platelets exceeding physiological levels. Platelets are anucleate cytoplasmic bodies formed through the fragmentation of megakaryocyte precursors. They circulate in the blood, expressing glycoproteins on their cell membranes, playing a key role in hemostasis and wound healing through the formation of fibrin clots [12].

A number of studies have shown that platelet counts in healthy individuals change throughout life. The normal platelet count for adults of both sexes ranges $(150\text{--}400)\times 10^9/\text{L}$. In children, platelet levels vary with age during growth and development. For example, in a one-month-old child, the platelet count is $(208\text{--}352)\times 10^9/\text{L}$, reaching about $(198\text{--}340)\times 10^9/\text{L}^5$ by age 11.

PRP is obtained by separating platelets from other blood components through the collection of a specific volume of the patient's blood followed by centrifugation. This process yields blood plasma with a high platelet concentration (exceeding the physiological baseline by 3–10 times). The final platelet concentration may vary depending on the system used [13, 14].

Currently, a substantial number of scientific studies are dedicated to randomized clinical trials on the use of PRP therapy for injuries and disorders of the musculoskeletal system [15, 16], including in professional athletes. However, Russia lacks a unified approved methodology for injections of PRP. To standardize the approach to PRP application for injuries and damage to large joints in junior athletes, two methods have been approved at the Federal Scientific and Clinical Center for Children and Adolescents: open and closed (Fig. 1).

When processed using a closed-loop system, platelets are not exposed to the external environment after blood collection. This system involves the use of a commercial kit, primarily in combination with additional centrifugation.

There are numerous (over 40) protocols and commercial systems for producing PRP; the relevant data are presented in Table.

The study by Jildeh et al. present a comparative analysis of PRP preparation methods using commercial systems. Technical specifications, cost, processing time, and centrifugation parameters of various commercially available PRP devices differ significantly. The physician independently determines the characteristics that best align with their PRP requirements [17].

CLINICAL CASE DESCRIPTION

Patient A, 16 years old (born 2007), a professional beach volleyball athlete, was under observation at the Traumatology Department of the Federal Scientific and Clinical Center for Children and Adolescents with the following diagnosis: S83.7 Injury of multiple structures of the knee joint. Partial tear of the anterior cruciate ligament (ACL) of the left knee joint. W09.3 Fall involving sports ground equipment during sports activities and competitions.

Medical History. The patient is the first child from a physiological pregnancy and spontaneous delivery. Birth weight was 3450 g, length 52 cm, Apgar score 8–9. Breastfeeding continued until 10 months. Psychomotor development during the first year was age-appropriate. Past infectious diseases: ARVI, chickenpox. Preventive vaccinations were administered according to the national immunization schedule. No prior surgical interventions.

History of Present Illness. In March 2025, during training, the patient sustained a left knee injury due to a fall. Given the trauma and severe pain, magnetic resonance imaging (MRI) of the injured joint was performed outpatient at the local clinic. The MRI findings indicated an isolated ACL injury of the left knee joint (Fig. 2A). Two days post-injury, the patient was examined by a trauma orthopedist at the Federal Scientific and Clinical Center for Children and Adolescents.

Status Localis. Moderately pronounced edema in the left knee joint; positive patellar ballotement sign; flexion limited to 90° due to pain. Provocative tests (Lachman test, anterior drawer test) could not be performed at this stage due to severe pain. Pain intensity assessed via the Visual Analog Scale (VAS) (0 = no pain, 10 = worst pain) was 5 points.

Based on the history, complaints, physical examination, and diagnostic results, the final diagnosis was “Isolated injury of the anterior cruciate ligament of the left knee joint.”

Management and Treatment Strategy. To reduce pain and stimulate regeneration of damaged tissues, a conservative treatment strategy was selected. This included immobilization of the knee joint (tutor for 2 weeks), troxerutin gel (for 2 weeks) cold therapy

⁵ Normal Platelet Count in Blood. URL: <https://wer.ru/articles/norma-trombotsitov-v-krovi/> (access date: 27.05.2025)

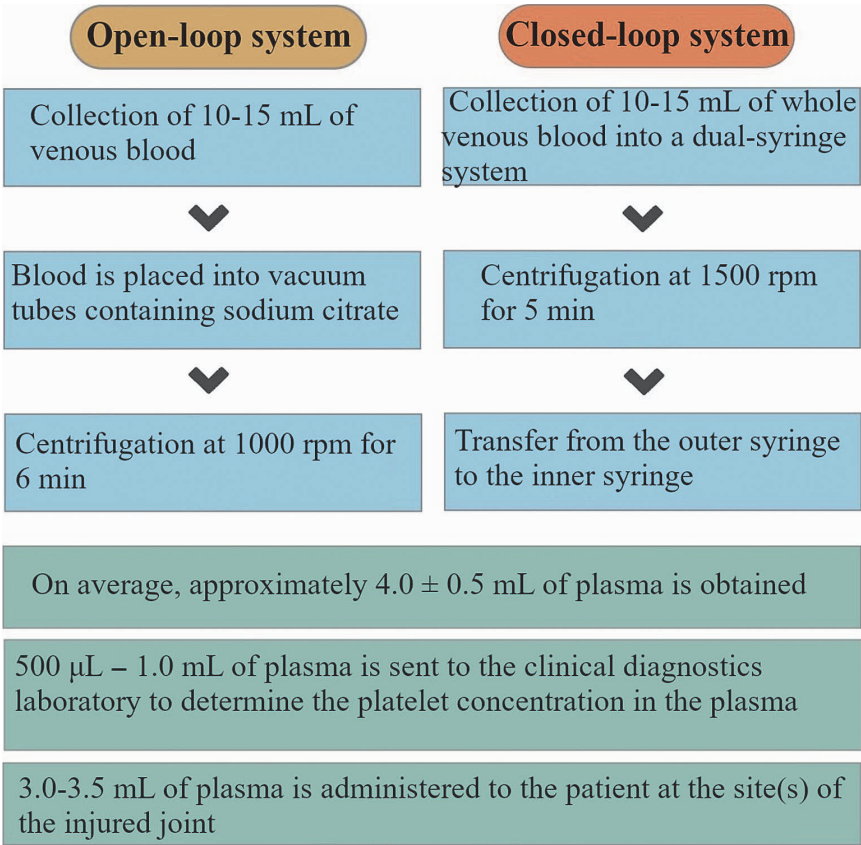


Figure adapted from [8]

Fig. 1. Methods of PRP application for injuries and damage to large joints in underage athletes

(3 days) for local treatment, of a hinged brace with gradual increase in flexion angle by 15–30° every 3 days, exclusion of running and jumping, and a course of PRP therapy (3 injections at 7-day intervals). After six months of the PRP therapy course, a follow-up MRI was conducted.

PRP Therapy. In accordance with the protocol developed and implemented at the Federal Scientific and Clinical Center for Children and Adolescents for candidate selection for PRP therapy, the patient was evaluated using inclusion criteria before initiating the PRP course. This included assessment of complete blood count (CBC) and inflammatory markers (C-reactive protein, CRP) to promptly identify signs of systemic inflammation or other contraindications. Additionally, prior to each injection, CBC was repeated to rule out potential contraindications (e.g., acute inflammatory processes, thrombocytopenia). Given normal laboratory values and no deviations from other inclusion criteria, the athlete received a course of PRP therapy consisting of three injections at seven-day intervals.

For platelet-rich plasma preparation, a closed-loop method using a dual-syringe system was selected: 15 mL of whole blood was collected from the medial cubital vein into Arthrex tubes and centrifuged at 1500 rpm for 5 min using a Rotofix 32A centrifuge. After blood component separation, the formed platelet-rich plasma

layer (approximately 5.0 mL) was transferred from the outer syringe to the inner syringe. A portion of the prepared material (approximately 1.0 mL) was sent to a clinical diagnostic laboratory for platelet concentration measurement, which confirmed a twofold increase in platelet count compared to baseline. PRP injections were administered percutaneously under ultrasound guidance. The procedure was performed under aseptic conditions after skin antisepsis, with the patient in a supine position and the knee flexed at 90°. The injection was delivered into the knee joint cavity via a lateral approach. The patient tolerated PRP therapy satisfactorily, with no adverse reactions reported.

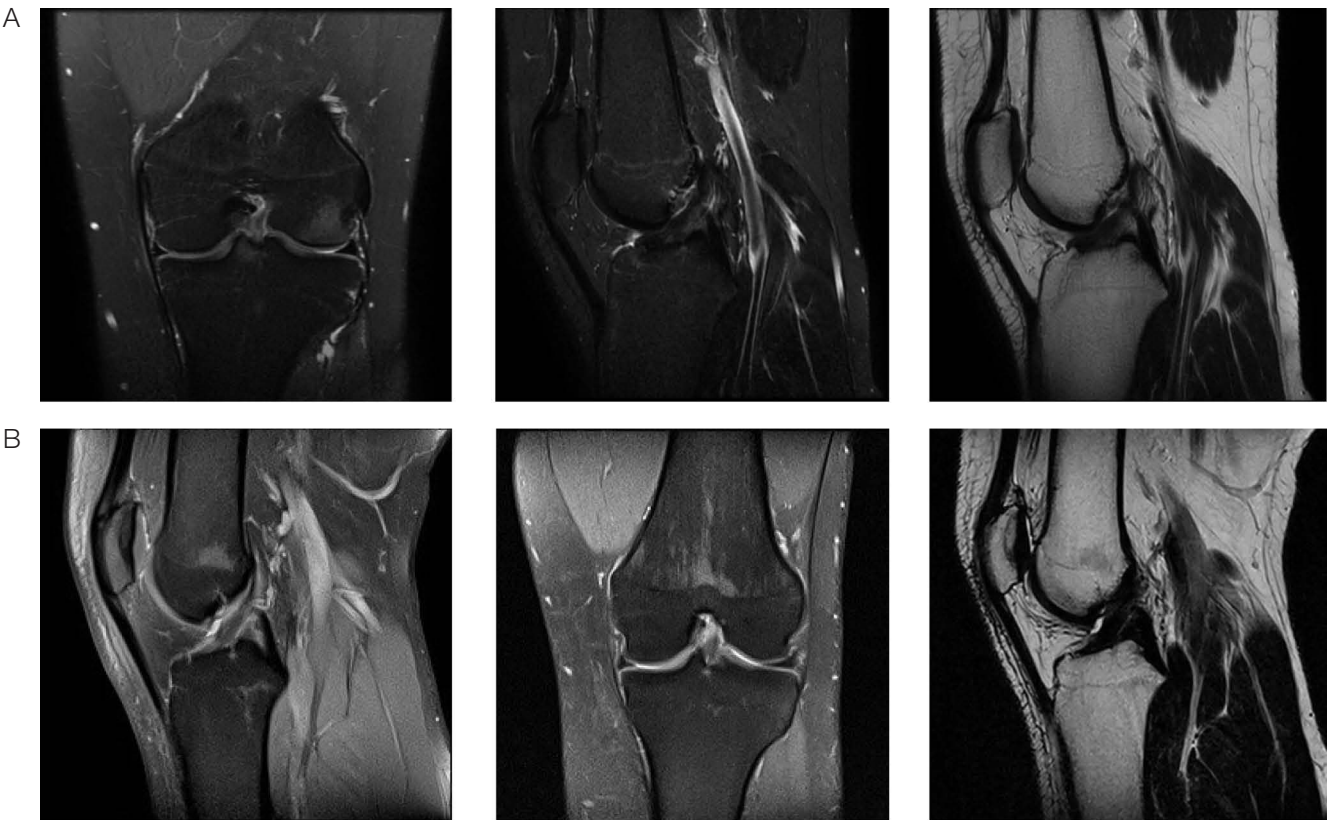
Therapy Results. After the completed course of PRP therapy, the patient noted improvement in knee joint function manifested in reduced pain syndrome (VAS – 3 points), improved flexion function, and decreased discomfort phenomena in the left knee joint during physical exercises.

The follow-up examination after six weeks showed a complete regression of the edema of the knee joint area, a full restoration of the joint flexion, and the absence of pain syndrome (VAS – 1 point). Slight limping was noted when leaning on the injured limb. Provocative tests (Lachman test and anterior drawer test) were questionable; however, no signs of pronounced instability were detected. Importantly for the athlete, gradual return to

Table. Point-of-Care processing methods for platelet-rich plasma

Name of Commercial Kit	Claimed Platelet Increase Fold (Times)	Platelet Increase Fold (Times)	Centrifugation Time (min)	Key Advantages	Disadvantages
ProofPoint	No data available	5.2	49	More than 4-fold increase in platelet count in plasma	Transfer via syringe. open system; 2 centrifugation stages
AcCELLerated	4	5.2	18	More than 4-fold increase in platelet count in plasma	Absent
Arthrex	2–3	4.2	15	Reduction of processing time; More than 4-fold increase in platelet count in plasma	Non-permanent increase in platelet count
Celling	No data available	2.7	29	Usability	Non-permanent increase in platelet count
Terumo	3.62	4.1	24	More than 4-fold increase in platelet count in plasma	Variability of results

Table prepared by the authors using own data [17]



MRI image obtained by the authors.

Fig. 2. Magnetic resonance imaging of the left knee joint: A — after injury; B — after treatment

previous sports load was noted, including running and cycling. Five months after the injury, the patient was able to resume gym training (leg press with 120 kg weight).

The follow-up examination six months after the injury showed the ability of the patient to walk independently and confidently, without limping. No edema in the left knee joint area was present; the patella was in the midline. Ballottement sign was negative, Lachman and anterior drawer tests were negative, symmetrical on both sides. No subjective or objective signs of knee joint instability were detected, VAS was 0 points. Therefore, according to control MRI data, restoration of the anterior cruciate ligament structure was confirmed (Fig. 2B).

Thus, this clinical case demonstrates the efficacy, safety, and good tolerability of PRP application for ACL injury in an underage professional athlete. Positive outcomes were observed both clinically — manifested as regression of pain assessed via VAS, restoration of joint function, and positive dynamics in provocative tests (Lachman test and anterior drawer test) — and through MRI data showing restoration of the anatomical integrity of the ligament. This highlights the importance of an individualized approach to treatment strategies for patients, particularly athletes with injuries and damage to large joints. The results align with current literature data, indicating the promise of therapeutic approaches in orthopedics and sports medicine utilizing regenerative medicine technologies.

CLINICAL CASE DISCUSSION

Anterior cruciate ligament (ACL) injury remains a common and severe trauma among professional athletes and sports enthusiasts [2]. Due to the high involvement of the ACL in knee mobility and stability, its injuries are of particular interest to sports medicine specialists, necessitating reduced rehabilitation time, lower probability of long-term complications, and faster recovery and return of athletes to elite sports. In this context, regenerative medicine technologies, including the use of platelet-rich plasma (PRP), hold a special place in orthopedics. Numerous research articles on PRP therapy have been published, demonstrating positive outcomes such as pain relief, stimulation of tissue regeneration, and accelerated healing processes in patients with musculoskeletal injuries [18]. PRP therapy is a minimally invasive method that can be used both as a monotherapy and in combination with conservative treatment. To accurately assess the effectiveness of PRP, comprehensive and dynamic clinical and instrumental examination is required.

Thorough history-taking, pain assessment, and physical examination are helpful in determining the most appropriate diagnostic tools. Some studies prioritize magnetic resonance imaging (MRI) for diagnosing ligamentous injuries of the knee joint in children [19].

Indeed, MRI is widely used for evaluating knee injuries, but its accuracy in cases of damage to various structures of the knee joint remains uncertain. However, for ACL injuries, the high sensitivity of this method amounting to 90.4% has been proven [20].

In the presented clinical case, the use of PRP for ACL injury in an underage professional athlete showed favorable results both in terms of pain relief and restoration of functional abilities of the injured limb. It is important to note that this method is safe when procedural requirements are met (asepsis, antisepsis, ultrasound guidance, etc.), cost-effective due to the use of the patient's own plasma, and yields rapid results. The use of a closed-loop system for PRP preparation minimized potential risks, reduced the consumption of medical supplies, and shortened the time required for transferring PRP between tubes, thereby enhancing economic efficiency.

CONCLUSION

The study presents standardized methodologies for PRP therapy in injuries and damage to large joints in underage athletes. The efficacy of PRP application for ACL injury in a professional beach volleyball athlete was evaluated. A set of trigger points to track dynamic changes during PRP therapy for ACL injuries was theoretically substantiated, including clinical presentation with pain assessment via VAS, physical examination data, results of specific functional tests (Lachman test and anterior drawer test), and MRI diagnostics. The presented clinical case demonstrates the effectiveness of PRP therapy, with positive dynamics on radiological diagnostic results, culminating in complete restoration of the anterior cruciate ligament structure within the period of six months.

Given the existing domestic and international experience of using PRP for diseases and injuries of large joints in older population cohorts, as well as the results obtained in this clinical case, it appears promising to continue the application of PRP in underage athletes with injuries and damage to large joints. Subsequent evaluation of the efficacy of the proposed method should consider injury localization, type of damaged tissue, time since injury, and rehabilitation period, with documentation of clinical and functional dynamics.

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