Review Article
https://doi.org/10.17816/2311-2905-2355

Current Concepts in Diagnostics and Treatment of Patellar Instability: Review

Vladimir V. Khominets, Dmitri A. Konokotin, Oleg V. Rikun, Aleksey O. Fedotov, Aleksey S. Grankin, Alexandr S. Vorobyev

Kirov Military Medical Academy, St. Petersburg, Russia

Abstract

Background. Patellar instability is one of the most common pathologies of the musculoskeletal system, predominantly observed in physically active young individuals. It ranks third in the structure of knee joint injuries after anterior cruciate ligament and meniscal injuries.

The aim of this review — to present modern perspectives on the diagnosis, principles, and surgical treatment techniques for patients with patellar instability based on an analysis of the literature.

Methods. Publications were searched in the PubMed/MedLine and eLIBRARY databases. A total of 112 foreign articles published between 1984 and 2023 and 12 domestic publications from 2011 to 2022 were found. During the analysis, 68 articles were selected, which had full texts or abstracts containing sufficient information on diagnostic methods, commonly used standard and modified surgical correction methods for patellar instability, and treatment protocols considering patient age structure, instability characteristics, and functional demands.

Results. A qualitatively new stage in the reconstructive and restorative surgery of patellar instability is the in-depth examination of patients to determine the extent of damage to the medial retinaculum and the presence of dysplastic changes in anatomical structures that provide normal biomechanics of the knee extensor apparatus. A strictly individual approach to the selection of surgical treatment methods considering risk factors contributing to the development of chronic patellar instability becomes of particular importance.

Conclusion. Precise restoration of the medial patellofemoral ligament, supplemented by the correction of identified dysplastic changes in anatomical formations of the knee joint area, allows for better functional outcomes in patients with acute and chronic patellar instability.

Keywords: patellar dislocation, patellar instability, medial patellofemoral ligament reconstruction, trochlear dysplasia.

Cite as: Khominets V.V., Konokotin D.A., Rikun O.V., Fedotov A.O., Grankin A.S., Vorobiev A.S. Current Concepts in Diagnostics and Treatment of Patellar Instability: Review. *Traumatology and Orthopedics of Russia*. 2023;29(2): 130-143. (In Russian). https://doi.org/10.17816/2311-2905-2355.

✉ *Dmitri A. Konokotin* e-mail: konokotin.dmitry@yandex.ru

Submitted: 20.01.2023. Accepted: 12.05.2023. Published: 09.06.2023.

Обзорная статья
УДК 616.718.49-007.281-07-08
https://doi.org/10.17816/2311-2905-2355

Современные подходы к диагностике и лечению нестабильности надколенника: обзор литературы

В.В. Хоминец, Д.А. Конокотин, О.В. Рикун, А.О. Федотов, А.С. Гранкин, А.С. Воробьев

ФГБВОУ ВО «Военно-медицинская академия им. С.М. Кирова» Минобороны России, г. Санкт-Петербург, Россия

Реферат

Актуальность. Нестабильность надколенника — одна из наиболее часто встречающихся патологий опорно-двигательного аппарата, наблюдающаяся преимущественно у физически активных молодых людей, которая занимает третье место в структуре повреждений области коленного сустава после травм передней крестообразной связки и менисков.

Цель обзора — на основании анализа данных литературы представить современные взгляды на диагностику, принципы и методики хирургического лечения пациентов с нестабильностью надколенника.

Материал и методы. Поиск публикаций осуществлялся в базах данных PubMed/MedLine и eLIBRARY. Всего было найдено 112 иностранных статей, опубликованных в период с 1984 по 2023 г., и 12 отечественных публикаций за 2011–2022 гг. В ходе анализа публикаций было отобрано 68 статей, для которых были доступны полные тексты или рефераты, содержащие достаточную информацию по методам диагностики и наиболее часто применяемым стандартным и модифицированным способам хирургической коррекции нестабильности надколенника, а также протоколы лечения рассматриваемой патологии с учетом характера нестабильности, возрастной структуры и функциональных запросов пациентов.

Результаты. Качественно новым этапом развития реконструктивно-восстановительной хирургии нестабильности надколенника является углубленное обследование пострадавших с определением степени повреждений медиального ретинакулюма и диспластических изменений анатомических структур, обеспечивающих нормальную биомеханику разгибательного аппарата коленного сустава. Особое значение приобретает строго индивидуальный подход к выбору метода хирургического лечения с учетом факторов риска, способствующих развитию хронической нестабильности надколенника.

Заключение. Прецизионное восстановление медиальной пателло-феморальной связки, дополненное по показаниям коррекцией выявленных диспластических изменений анатомических образований области коленного сустава, позволяет получить лучшие функциональные результаты у больных с острой и хронической нестабильностью надколенника.

Ключевые слова: вывих надколенника, нестабильность надколенника, реконструкция медиальной пателло-феморальной связки, дисплазия блока бедренной кости.

Для цитирования: Хоминец В.В., Конокотин Д.А., Рикун О.В., Федотов А.О., Гранкин А.С., Воробьев А.С. Современные подходы к диагностике и лечению нестабильности надколенника: обзор литературы. *Травматология и ортопедия России*. 2023;29(2):130-143. https://doi.org/10.17816/2311-2905-2355.

Конокотин Дмитрий Александрович; e-mail: konokotin.dmitry@yandex.ru

Рукопись получена: 20.01.2023. Рукопись одобрена: 12.05.2023. Статья опубликована: 09.06.2023.

BACKGROUND

Patellar instability is one of the most common pathologies of the musculoskeletal system, primarily observed in physically active young individuals [1]. It ranks third in the incidence of knee joint injuries after meniscal tears and anterior cruciate ligament ruptures, accounting for 3.3% [2].

Primary patellar dislocation mostly occurs as a result of acute trauma. According to M. Moiz et al., conservative treatment of traumatic patellar dislocations leads to the development of chronic instability in one-third of the affected patients (31%) [3]. A study by R.A. Magnussen et al. showed that only 26.4% of patients regain knee joint function to the level of their previous physical activity after conservative treatment [4]. L.S. Huntington et al. confirmed that conservative treatment of primary patellar dislocations is accompanied by recurrence of instability in 33.6% of cases, significantly affecting the patients' quality of life [5]. E.E. Salonen et al. demonstrated that chronic patellar instability is associated with a high risk of early development of patellofemoral joint osteoarthritis due to constant cartilage trauma in the patellar joint and the femoral block [6]. A.K. Orletsky et al. reported a lower risk of patellar dislocation recurrence after operative treatment compared to conservative treatment, but a higher risk of developing osteoarthritis of the patellofemoral joint following surgery [7].

Currently, the question of selecting indications for operative treatment in patients with primary patellar dislocation remains debatable. In the last decade, special attention has been given to the biomechanical aspect of instability development [8]. The conducted studies have demonstrated that anatomical features of the knee joint extensor apparatus, such as tibial tuberosity dysplasia, lateralization of the tibial tuberosity, high patellar position, excessive femoral anteversion, and torsion of the tibia, significantly influence the biomechanics of the patellofemoral joint. These factors should be taken into account when choosing treatment strategies for both acute and chronic instability [9, 10, 11, 12].

The aim of this review is to present contemporary views on the diagnosis, principles, and surgical treatment techniques for patients with patellar instability based on an analysis of the literature.

METHODS

The search for publications was conducted in the PubMed/MedLine and eLIBRARY databases. The search keywords and phrases included: patellar dislocation, patellar instability, medial patellofemoral ligament, tibial tuberosity dysplasia, medial patellar retinaculum, tibial tubercle, trochleoplasty, patellar instability, recurrent patellar instability, patellar dislocation, medial patellofemoral ligament reconstruction, MPFL, tibial tubercle osteotomy, trochlear dysplasia, femoral osteotomy, trochleoplasty.

A total of 112 foreign articles published from 1984 to 2023 and 12 domestic publications from 2011 to 2022 were found. During the analysis of the publications, 68 articles with full texts or abstracts containing sufficient information about diagnostic methods, commonly used standard and modified surgical correction techniques for patellar instability, as well as treatment protocols considering patient age, type of instability, and functional demands were selected.

RESULTS

Diagnostic features

The diagnosis of patellar instability, in addition to clinical examination, is based on determining numerous indicators that characterize the individual anatomical features of the knee joint extensor apparatus. The characteristics of the morphology of the femoral block and patella, the height of the patella relative to the femur, and the lateralization of the tibial tuberosity are the main interrelated signs that define the diagnosis of "patellar instability." In addition to their diagnostic value, indicators such as the tibial tuberosity-trochlear groove distance (TT-TG), the angle of the femoral trochlear groove, and the height ratios of the patella and the type of femoral block structure assist in choosing the surgical treatment approach [13].

Assessment of patella height

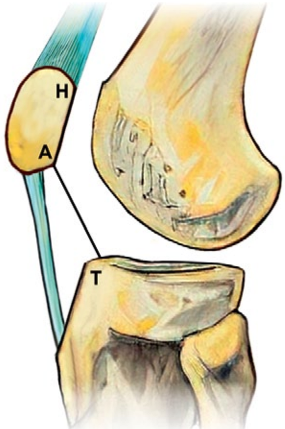
The most straightforward and surgically correctable anatomical anomaly of the knee joint is the high patella position relative to the femoral block. The higher the patella is positioned, the greater the flexion angle at which it engages with the femoral trochlear groove, and the less stable the patella becomes. According to Ch. Huber et al., if the patella fails to engage with the trochlear groove at a flexion angle greater than 30°, it indicates a potentially high risk of instability [14]. Usually, the assessment of patella height is performed using a lateral radiograph of the knee joint at a 30° flexion position [9, 15].

According to most authors, the Caton-Deschamps index is the most informative, with a normal range of 0.6-1.3 [13, 14, 15] (Fig. 1). R. Neyret et al. found this anomaly in 48% of patients with patellar instability and only 12% of individuals in the control group without a history of patellar dislocation [16].

Different opinions on the magnitude of the Caton-Deschamps index can be found in the literature. An index range of 1.2-1.3 is considered mild, while 1.3-1.4 is considered severe. Until now, most authors have followed the recommendations of H. Dejour et al. and performed surgical correction when the index exceeds 1.2 [9]. In the last decade, publications have emerged suggesting that surgery is indicated when the index is above 1.4 or 1.3 [13, 17, 18]. However, the patella height index alone, increased to 1.2 or even 1.3, is not a direct indication for surgical correction since patella lowering in cases of instability is rarely considered as an isolated procedure and is usually performed in combination with correction of other extensor apparatus anomalies that can affect this indicator's change.

Lateralization of the tibial tuberosity

The distance from the center of the femoral block to the attachment site of the patellar ligament on the tibial tuberosity in the frontal plane significantly influences the magnitude of lateralizing forces on the patella during flexion-extension movements of the knee joint. Lateralization of the tibial tuberosity is an external, easily detectable sign of excessive rotation of the proximal portion of the tibial tuberosity. This anomaly has long been known, but it was only with the widespread clinical use of CT and MRI that precise measurements and discussions of the quantitative aspect of this indicator became possible. These measurements are performed on axial MRI and CT scans and are referred to as the TT-TG (tibial tubercle-trochlear groove) distance or index. A commonly accepted indication for surgical correction is a distance of 20 mm or more [19] (Fig. 2).



CDI = HA/AT

Fig. 1. Calculation of the Caton-Deschamps index: AT — line connecting the lower edge of the patellar articular facet to the anterior edge of the tibial plateau; HA — line corresponding to the articular surface of the patella; CDI — Caton-Deschamps index, the ratio of the length of the AT line to the HA line

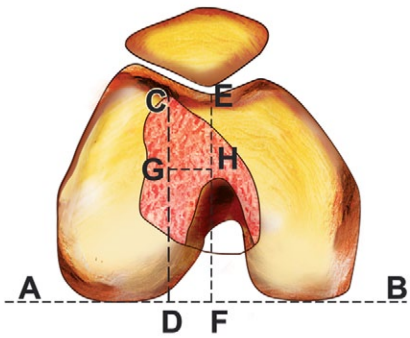


Fig. 2. Scheme for calculating the TT-TG index in the axial plane: AB — tangent line to the femoral condyles; CD — perpendicular from the center of the tibial tuberosity to the line of the femoral condyles; EF — perpendicular from the center of the articular surface of the femoral block to the line of the femoral condyles; GH — distance between the center of the articular surface of the femoral block and the center of the tibial tuberosity

According to S. Tan et al., the measurement of the TT-TG index significantly differs between CT and MRI. Their analysis showed that for the same patients with patellar instability, the average index measured on MRI was 15.3 mm, while on CT, it was 18.3 mm. However, measurements performed on CT are considered more reliable [20].

Objective measurement of the TT-TG distance is an important step in diagnosing and planning the surgical correction of patellar instability. However, this method presents significant challenges in cases of block dysplasia, especially type D, when determining the position of the tibial tubercle on its flat or asymmetrically convex surface.

To improve the accuracy of this measurement, G. Seitlinger et al. proposed using the attachment point of the posterior cruciate ligament on the lateral wall of the medial femoral condyle as a more constant reference point on the distal femoral epiphysis, which is independent of the degree of block dysplasia. They named this indicator the TT-PCL (tibial tubercle-posterior cruciate ligament) index and established its upper normal limit at 24 mm [21].

Z. Xu et al. recommended a different modification of this indicator, replacing the point of the trochlear groove with a point located at the apex of the "Roman arch" on the posterior surface of the intercondylar fossa of the femur. This yields the TT-RA index, with a normal value of less than 26 mm [22].

A comparative analysis conducted by T.J. Kim et al. found that the accuracy of calculations for the TT-TG and TT-PCL indices is influenced by the consideration of femoral anteversion, medialization of the intercondylar groove, and the specific anatomical structure of the proximal tibial tuberosity, which is not always taken into account in their determination. The authors noted that the parameters of the TT-RA index are not affected by anatomical variations of the tibial tuberosity, thereby minimizing the margin of error, and this method can be an alternative for assessing lateralization of the tibial tuberosity, especially when TT-TG measurement is inconclusive [23]. However, Z. Xu et al. argue that, compared to other parameters, the TT-TG distance still has the greatest diagnostic value when considering all the anatomical features of the knee joint extensor apparatus [24].

Diagnosis of types of femoral block dysplasia

The most important and commonly observed manifestation of knee joint dysplasia, which predisposes to patellar instability and creates difficulties in its correction, is the anomalous shape of the articular surface of the femoral block. This pathology is specifically understood as "knee joint dysplasia" in the narrow sense. The diagnosis of this anatomical feature is based on the analysis of knee joint X-rays in the strictly lateral projection [9, 16, 25, 26] (Fig. 3).

In 2010, D. Dejour and P. Saggin proposed a classification of femoral block dysplasia, which is an improved version of N. Dejour's classification and forms the basis of modern surgical treatment schemes for patients with patellar instability. The classification identifies four main types of block dysplasia, characterized by deformations of its articular surface [27] (Fig. 4).

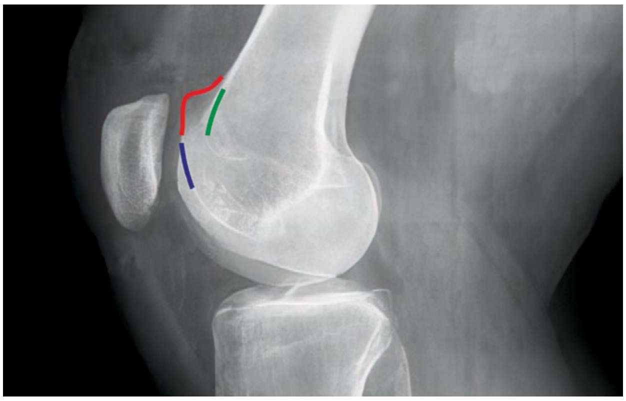


Fig. 3. X-ray of the knee with signs of trochlear dysplasia in the lateral projection:
blue line — «crossing sign», representing the deepest point of the trochlear groove crossing the anterior border of the femoral condyles; red line — «supratrochlear spur», the prominence of the trochlea on the anterior side of the femoral cortex; green line — «double contour», hypoplastic medial facet located behind the lateral facet

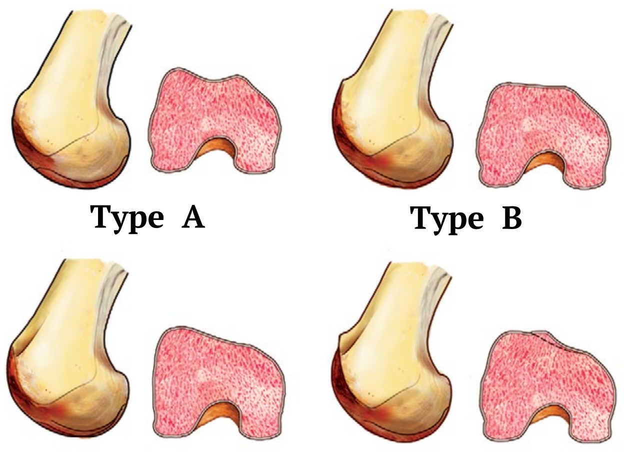


Fig. 4. D. Dejour classification of trochlear dysplasia

In practice, D. Dejour's classification places the main emphasis on the analysis of tomograms in the axial plane, which can be easily obtained during standard CT or MRI scans, unlike X-rays in the strictly lateral projection. However, these tomograms do not have such clear quantitative criteria, making it difficult to objectively analyze the results of surgical patellar stabilization. The presence of severe dysplasia types B, C, and D complicates the surgical correction of patellar instability due to the pathological biomechanics in the femoral-patellar joint of the knee [28, 29, 30].

The severity of the dysplasia type also influences the condition of the patellar cartilage. Progressive hypoplasia of the lateral femoral condyle, together with the incompetence of the medial retinaculum, leads to more pronounced traumatic damage to the patellar articular facet and, consequently, the development of early patellofemoral arthritis [31].

Risk factors and specifics of surgical correction

Restoration of the Medial Patellofemoral Ligament (MPFL)

The leading anatomical factor contributing to the development of chronic patellar instability is the functional insufficiency of the medial patellofemoral ligament (MPFL), which provides more than 60% resistance against lateral dislocation of the patella during stress loads within a limited range of knee joint motion. Currently, the restoration of the MPFL, which contributes to the elimination of frontal patellar instability, is the goal of surgical treatment for this condition [32, 33, 34].

According to anatomical and biomechanical studies, the knee joint's medial retinaculum, in addition to the MPFL, has another capsular ligament called the medial patellotibial ligament (MPTL). The MPTL acts as an auxiliary static stabilizer of the patella when the leg is flexed beyond 30°, where the influence of the MPFL physiologically weakens. Combined reconstruction of these two ligaments is considered an option for additional reinforcement during MPFL restoration in cases of increased risk of patellar instability recurrence, caused by high patellar positioning and abnormal lateralization of the tibial tubercle, and as an alternative to tibial tubercle transposition [35, 36, 37].

Anatomical ligament reconstruction has an undeniable priority over primary suture or local tissue plastic repair [38, 39, 40]. The success lies in the anatomical placement of the graft [39]. The key aspect of the reconstruction is the correct selection of the fixation point on the medial surface of the medial femoral condyle, located in the posterior-upper segment of the area where the damaged native ligament was attached. Such positioning, while maintaining normal knee joint range of motion, results in less than 4% change in graft length. The resulting graft anisometry ensures proper biomechanics and reliable stabilization of the patella at its most vulnerable position during the initial flexion of the leg, when the graft experiences maximum traction forces, serving as the only structure preventing lateral dislocation until it enters the femoral trochlear groove [15, 38]. Typical anatomical anomalies of the knee joint, based on its dysplasia, as well as incorrect placement of the fixation point on the femoral condyle, hinder the proper functioning of the graft and greatly increase the load on it, creating conditions for the formation of persistent contractures and recurrent instability.

Currently, the Schöttle method is used for intraoperative X-ray video control to determine the fixation point of the graft in the area of the medial femoral condyle. This technique significantly improves accuracy, reduces invasiveness, and shortens the operation time [41] (Fig. 5).

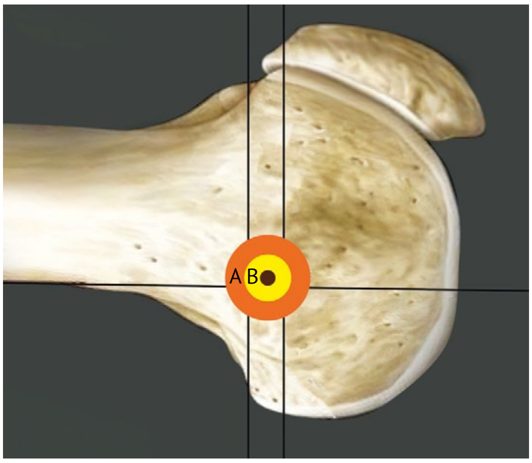


Fig. 5. Scheme of tunnel formation for fixation of the MPFL graft in the femoral condyle:
A — satisfactory tunnel positioning;
B — correct tunnel location

For severe degrees of femoral block dysplasia (Types C and D according to D. Dejour), the use of X-ray methods may alter the spatial positioning of landmarks and lead to serious errors in calculations. To avoid this, it is advisable to combine radiographic and traditional anatomical landmarks, complementing them with a functional test aimed at evaluating the tension of the MPFL graft at different angles of knee joint flexion [30].

Meticulous calculations for the correct selection of the graft fixation point in the femoral tunnel, which make up the majority of technical errors in MPFL reconstructions, can result in changes in graft tension in different knee joint positions and anomalies in the patellar motion trajectory [34]. Typical deviations from the anatomical attachment point of the MPFL on the medial femoral condyle (Schöttle point) proximally and anteriorly during flexion beyond 50-60° lead to significant graft tension and the formation of persistent extension contracture. During rehabilitation, with the forced restoration of motion amplitude through aggressive physical therapy, chondromalacia of the patella and femoral trochlea can occur, ultimately leading to graft damage, plastic elongation, or complete rupture with recurrent instability [39, 42, 43]. According to Th. Neri et al., errors in femoral tunnel placement during MPFL reconstructions can reach up to 33% [44].

The anatomical fixation of the graft on the proximal half of the medial border of the patella restores its ability to simultaneously act on the quadriceps tendon. There are two main methods of fixation: placing the graft in bony tunnels or in a bone trough along the edge of the patella, secured with interference screws, anchors, or transosseous sutures. The main requirements in this regard are the strength of graft fixation in the early postoperative period and minimizing the risk of fractures of the patella at the tunnel sites in the future [35]. V.A. Raoulis et al. did not find significant differences among the three aforementioned methods of graft fixation in the patellar area, although the use of interference screws showed a higher degree of graft fixation stiffness, and patients reported less pronounced pain in the anterior aspect of the knee joint when using anchor or suture-button fixators [45].

Failures in restoring the proper trajectory of patellar motion during MPFL reconstruction can also be associated with excessive graft tension, leading to medial subluxation. In most cases, the occurrence of this complication is provoked by an extensive release of the lateral retinaculum with resection of the lateral patellofemoral ligament and detachment of a portion of the lateral quadriceps tendon [46]. In cases of isolated MPFL reconstruction, it is generally recommended to avoid this procedure. If it is not possible to avoid lateral release due to persistent contracture of the lateral retinaculum, it is advisable to perform an elongation plasty of the lateral patellofemoral ligament rather than simple resection [47, 48].

The stability and normal kinematics of the patella are the result of the complex interaction between muscles, the capsuloligamentous apparatus, normal bone geometry of the femorotibial joint surfaces, and a stable supportive limb balance. However, a significant factor that influences the outcomes of patellar instability treatment, even with impeccable MPFL reconstruction, is the frequently encountered anatomical anomaly of the femoral block and the knee extensor apparatus, which have a dysplastic nature [49].

Currently, it is widely accepted that anatomical MPFL reconstruction generally leads to good anatomical and functional results with a relatively low rate of complications, especially for patients with low functional demands [18, 29, 50, 51, 52]. However, the outcomes of such surgeries largely depend on the correct positioning of the graft and, most importantly, on risk factors associated with anatomical anomalies of dysplastic origin. Several authors note that without considering these factors, simple isolated MPFL reconstruction provides acceptable restoration of knee joint function in less than 40% of cases, with a recurrence rate of patellar instability ranging from 30% to 35% [43, 49, 53, 54]. M.J. Feucht et al. reported that after isolated MPFL reconstruction, the main complications leading to revision surgery were recurrent instability (35.6%) and persistent joint contracture (22.2%) [55].

Bone plastic surgeries

In 1994, N. Dejour et al. identified four risk factors for the development of patellar instability: femoral trochlear dysplasia, quadriceps dysplasia with a lateral tilt of the patella greater than 20°, a high-riding patella with a Caton-Deschamps index greater than 1.2, and excessive lateralization of the tibial tubercle with a TT-TG index greater than 20 mm. They classified femoral trochlear dysplasia based on lateral radiographic signs, including "crossing sign," "trochlear spur," which protrudes more than 3 mm above the anterior surface of the femoral diaphysis, and shallow trochlear groove with a depth reduction of 4 mm or more (see Figure 3). They also associated anatomical anomalies predisposing to lateral patellar instability with changes in the rotational profile of the lower limbs, such as excessive internal rotation of the femoral condyles more than 25° and external torsion of the tibia more than 35° [8, 9, 28, 56].

The complexity of assessing the degree of various dysplastic manifestations in the structures of the knee extensor apparatus and their impact on surgical outcomes arises from the fact that some authors consider Type A dysplasia as pathology, while others classify it as a borderline condition or even a conditional norm. R.N. Steensen et al. found that dysplastic anomalies of the knee joint were present in 58.3% of patients with patellar instability, compared to only 1.7% in the control group. Femoral trochlear dysplasia was observed in 68.3% of patients and 5.8% of individuals in the control group, high-riding patella in 60% and 20.8%, and increased TT-TG distance in 42% and 3.2%, respectively. They emphasized the significance of spatial deformations of the lower limb at the knee joint level in the frontal plane (valgus deviation of the tibia) and horizontal plane (internal torsion of the femur, external torsion of the tibia) [57].

Some authors note that typically, patients present a combination of these two types of anatomical lower limb changes, and an increased TT-TG index, pronounced valgus deformity of the lower limb, and dysplasia of types B, C, and D correlate with an increased risk of "hidden" torsional deformations of the limb [55, 58].

Correction of lateralization of the tibial tubercle

Surgical treatment of patients with an increased TT-TG index involves its reduction through medial transposition of the tibial tubercle along with the attachment site of the patellar ligament, according to the Elmslie-Trillat procedure [59] (see Figure 6).

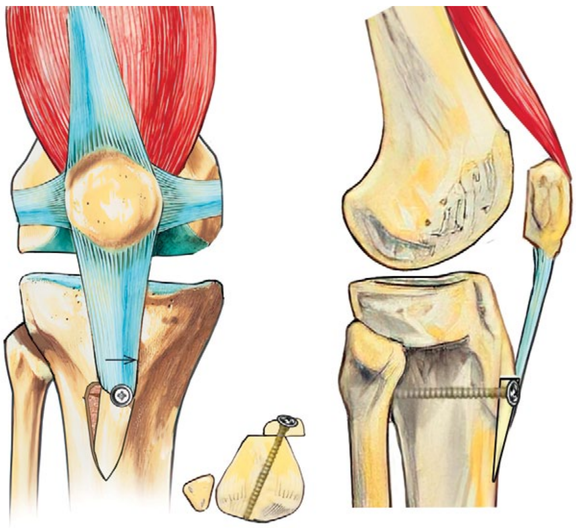


Fig. 6. Scheme of medializing transposition of the tibial tuberosity according to Elmslie-Trillat

The technical simplicity and biomechanical effect of tibial tubercle transposition in cases of increased TT-TG index in correcting dysplastic patellar instability explain the popularity of this versatile surgical method in modern comprehensive treatment of this pathology. C.E. Franciozi et al. suggest that in addition to MPFL reconstruction, medialization or anteromedialization of the tibial tubercle according to Fulkerson should be performed when the TT-TG index exceeds 17 mm, achieving a tubercle position of 10-12 mm [60].

Usually, not only medialization but also medialization with distalization is performed, as excessive lateralization of the tubercle is often associated with a high-riding patella. In the context of pronounced dysplasia of types B, C, and D, the possibility of accompanying rotational and frontal deformations at the knee joint level, which can influence the true value of the TT-TG index, should be considered [48]. According to L. Jud et al., during high tibial tubercle derotational osteotomy, each degree of internal detorsion is accompanied by a decrease in the TT-TG index by 0.68 mm [61].

It is believed that additional surgical procedures, primarily tibial tubercle transposition, increase the duration of the rehabilitation period and may impact the final outcomes [39]. One challenging combination for choosing the surgical treatment approach is type D dysplasia combined with a TT-TG index greater than 20 mm [62]. L. Hiemstra et al. explain the increased risk of recurrence associated with type B and especially type D dysplasias, characterized by a pronounced trochlear bump exceeding 5 mm [63]. In such cases, trochleoplasty is recommended, and an alternative option is medialization-distalization transposition of the tibial tubercle, which allows restoring the anatomical and biomechanical relationship between the patella and the femoral trochlea without directly correcting the femur [30, 64] (see Figure 7).

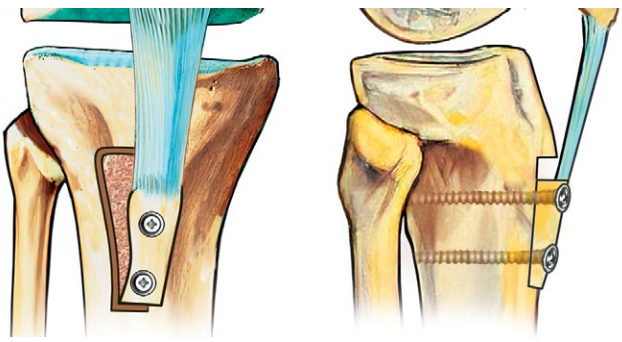


Fig. 7. Scheme of distalization and medialization of the tibial tuberosity (DMTT)

Correction of femoral bone anatomical changes

Data on the frequency of femoral trochlear dysplasia of different types are quite inconsistent, which is likely due to the subjective nature of their assessment. According to several authors, through detailed CT and MRI examinations, femoral trochlear dysplasia is detected in 65-85% of patients with symptomatic patellar instability and in 2-10% of individuals in control groups [5, 16]. A study by J.N. Liu et al. showed that 92% of patients undergoing surgery for patellar instability exhibited signs of trochlear dysplasia, including type A (8%), B (23%), C (26%), and D (43%) [50]. In 2020, a group of authors from the Technical University of Munich reported that all examined patients with patellar instability (151 patients) had anatomical signs of trochlear dysplasia. Mild type A dysplasia was observed in 33% of cases, while severe dysplasia of types B, C, and D was present in 67% [58].

According to A. Geierlehner et al., the majority of orthopedic surgeons, including those specializing in general reconstructive knee surgery, avoid patients with complex dysplastic anomalies or limit their treatment to a set of simpler and typical procedures such as MPFL reconstruction combined with lateral retinaculum lengthening and tibial tubercle transposition [51].

Modern pathogenetically justified surgical treatment of trochlear dysplasia involves a subchondral reconstruction of the deepened femoral trochlea (trochleoplasty), which is technically complex and invasive, thus having limited indications primarily for severe dysplasia (types B and D) with an abnormal trajectory of the unstable patella. Therefore, in practice, these procedures are mostly indicated for severe dysplasia, especially in revision stabilizations of the knee joints. The main goal of such surgeries is the resection of the wedge-shaped prominence characteristic of the most severe form of trochlear dysplasia (type D), resulting in the formation of an anatomically concave surface that normalizes the patellar trajectory and stabilizes the patella [28, 64, 65] (see Figure 8).

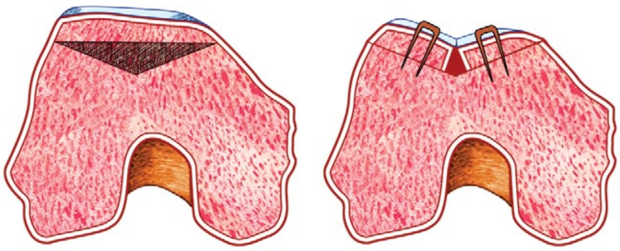


Fig. 8. Scheme of trochleoplasty according to D. Dejour (2010)

According to several authors, for patients with patellar instability rarely accompanied by significant femoral trochlear dysplasia, it is more reasonable to limit the treatment to MPFL reconstruction combined with tibial tubercle transposition. In cases of pronounced valgus deformity of the limb at the knee joint level, varus osteotomy of the femur or derotational osteotomy may be performed. In cases of rigid lateral retinaculum, this combination can be supplemented with lengthening plastic surgery of the lateral patellofemoral ligament, eliminating rotational stress on the extensor apparatus of the knee joint. If this condition is not feasible, additional external fixation of the patella with a special brace can be considered [66, 67, 68].

S. Zaffagnini et al. also note that performing unjustified trochleoplasty in cases of relatively simple dysplasia types A and C does not lead to a significant reduction in the recurrence of instability. For such patients, traditional MPFL reconstruction, either in isolation or combined with tibial tubercle transposition, is appropriate. However, for severe forms of dysplasia (types B and D), a combination of trochleoplasty with MPFL reconstruction contributes to real improvements in outcomes in both revision and primary surgeries [66].

CONCLUSION

The foundation of modern organ-preserving surgery for patellar instability, regardless of the timing of the procedure, lies in an individualized approach to selecting the method and extent of intervention. In all cases, the restoration of the integrity of the MPFL as a key element of the medial retinaculum is mandatory. The indications for additional correction of anatomical features of the extensor apparatus of the joint are determined by the degree of dysplasia and associated biomechanical abnormalities, patient age, and functional demands.

DISCLAIMERS

Author contribution

Khominets V.V. — the design, the writing and the drafting of the article.

Konokotin D.A. — the conception, data collection and processing, the writing of the article.

Rikun O.V. — data collection and processing, he writing and the drafting of the article.

Fedotov A.O. — he conception, the writing of the article.

Grankin A.S. — the writing and the drafting of the article.

Vorobiev A.S. — data collection and processing.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

Funding source. This study was not supported by any external sources of funding.

Disclosure competing interests. The authors declare that they have no competing interests.

Ethics approval. Not applicable.

Consent for publication. Not required.

REFERENCES

1. Sanders T.L., Pareek A., Hewett T.E., Stuart M.J., Dahm D.L., Krych A.J. Incidence of first-time lateral patellar dislocation: a 21-year population-based study. *Sports Health.* 2018;10(2):146-151. doi: 10.1177/1941738117725055.
2. Majewski M., Susanne H., Klaus S. Epidemiology of athletic knee injuries: A 10-year study. *Knee*. 2006;13(3):184-188. doi: 10.1016/j.knee.2006.01.005.
3. Moiz M., Smith N., Smith T.O., Chawla A., Thompson P., Metcalfe A. Clinical Outcomes After the Nonoperative Management of Lateral Patellar Dislocations: A Systematic Review. *Orthop J Sports Med.* 2018;6(6):2325967118766275. doi: 10.1177/2325967118766275.
4. Magnussen R.A., Verlage M., Stock E., Zurek L., Flanigan D.C., Tompkins M. et al. Primary patellar dislocations without surgical stabilization or recurrence: how well are these patients really doing? *Knee Surg Sports Traumatol Arthrosc*. 2017;25(8):2352-2356. doi: 10.1007/s00167-015-3716-3.

5. Huntington L.S., Webster K.E., Devitt B.M., Scanlon J.P., Feller J.A. Factors associated with an increased risk of recurrence after a first-time patellar dislocation. A systematic review and meta-analysis. *Am J Sports Med.* 2019;48(10):2552-2562. doi: 10.1177/0363546519888467.
6. Salonen E.E., Magga T., Sillanpää P.J., Kiekara T., Mäenpää H., Mattila V.M. Traumatic patellar dislocation and cartilage injury: a follow-up study of long-term cartilage deterioration. *Am J Sports Med.* 2017;45(6): 1376-1382. doi: 10.1177/0363546516687549.
7. Orletskiy A.K., Timchenko D.O., Gordeev N.A. Development of approaches to treatment of knee instability. *N.N. Priorov Journal of Traumatology and Orthopedics*. 2021;28(1):109-120. (In Russian). doi: 10.17816/vto63217.
8. Balcarek P., Oberthür S., Hopfensitz S., Frosch S., Walde T.A., Wachowski M.M. et al. Which patellae are likely to redislocate? *Knee Surg Sports Traumatol Arthrosc.* 2014;22(10):2308-2314. doi: 10.1007/s00167-013-2650-5.
9. Dejour H., Walch G., Nove-Josserand L., Guier C. Factors of patellar instability: an anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc.* 1994;2(1):19-26. doi: 10.1007/BF01552649.
10. Koh J.L., Stewart C. Patellar instability. *Clin Sports Med.* 2014;33(3):461-476. doi: 10.1016/j.csm.2014.03.011.
11. Lewallen L., McIntosh A., Dahm D. First-time patellofemoral dislocation: risk factors for recurrent instability. *J Knee Surg.* 2015;28(4):303-309. doi: 10.1055/s-0034-1398373.
12. Pruneski J., O'Mara L., Perrone G.S., Kiapour A.M. Changes in Anatomic Risk Factors for Patellar Instability During Skeletal Growth and Maturation. *Am J Sports Med.* 2022;50(9):2424-2432. doi: 10.1177/03635465221102917.
13. Thakkar R.S., Del Grande F., Wadhwa V., Chalian M., Andreisek G., Carrino J.A. et al. Patellar instability: CT and MRI measurements and their correlation with internal derangement findings. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(9):3021-3028. doi: 10.1007/s00167-015-3614-8.
14. Huber Ch., Zhang Q., Taylor W.R., Amis A.A., Smith C., Nasab S.H.H. Properties and function of the medial patellofemoral ligament A systematic review. *Am J Sports Med.* 2020;48(3):754-766. doi: 10.1177/0363546519841304.
15. Ragot L., Gerber F., Lannes X., Moerenhout K. The use of a 30-degree radiolucent triangle during surgery in distal avulsion fractures of the patella. *J Orthop Surg Res.* 2023;18(1):204. doi: 10.1186/s13018-023-03631-w.
16. Neyret P., Robinson A.H.N., Le Coultre B., Lapra C., Chambat P. Patellar tendon length – the factor in patellar instability? *Knee*. 2002;9(1):3-6. doi: 10.1016/s0968-0160(01)00136-3.
17. Fathalla I., Holton J., Ashraf T. Examination under anesthesia in patients with recurrent patellar dislocation: prognostic study. *J Knee Surg.* 2019;32(4):361-365. doi: 10.1055/s-0038-1641174.
18. Zhang L., Li Z. Long-term clinical results of double bundle reconstruction of the medial patellofemoral ligament for patellar instability. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(2):153-159. doi: 10.1055/s-0038-1636913.
19. Luceri F., Roger J, Randelli P.S., Lustig S., Servien E. How does isolated medial patellofemoral ligament reconstruction influence patellar height? *Am J Sports Med.* 2020;48(4):895-900. doi: 10.1177/0363546520902132.
20. Tan S.H.S., Hui S.J., Doshi C., Wong K.L., Lim A.K.S., Hui J.H. The Outcomes of Distal Femoral Varus Osteotomy in Patellofemoral Instability: A Systematic Review and Meta-Analysis. *J Knee Surg.* 2020;33(5):504-512. doi: 10.1055/s-0039-1681043.
21. Seitlinger G., Scheurecker G., Högler R., Labey L., Innocenti B., Hofmann S. Tibial tubercle-posterior cruciate ligament distance: a new measurement to define the position of the tibial tubercle in patients with patellar dislocation. *Am J Sports Med.* 2012;40(5):1119-1125. doi: 10.1177/0363546512438762.
22. Xu Z., Zhang H., Fu B., Mohamed S.I., Zhang J., Zhou A. Tibial Tubercle-Roman Arch Distance: A New Measurement of Patellar Dislocation and Indication of Tibial Tubercle Osteotomy. *Orthop J Sports Med.* 2020;8(4):2325967120914872. doi: 10.1177/2325967120914872.
23. Kim T.J., Lee T.J., Song H.S., Bae J.H. The Tibial Tuberosity-Rotational Angle as a Novel Predisposing Parameter for Patellar Dislocation. *Orthop J Sports Med.* 2022;10(12):23259671221142626. doi: 10.1177/23259671221142626.
24. Xu Z., Zhang H., Yan W., Qiu M., Zhang J., Zhou A. Validating the Role of Tibial Tubercle-Posterior Cruciate Ligament Distance and Tibial Tubercle-Trochlear Groove Distance Measured by Magnetic Resonance Imaging in Patients With Patellar Dislocation: A Diagnostic Study. *Arthroscopy*. 2021;37(1):234-242. doi: 10.1016/j.arthro.2020.09.004.
25. Zhang Z., Zhang H., Song G., Zheng T., Ni Q., Feng H. Increased femoral anteversion is associated with inferior clinical outcomes after MPFL reconstruction and combined tibial tubercle osteotomy for the treatment of recurrent patellar instability. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(7):2261-2269. doi: 10.1007/s00167-019-05818-3.
26. Lee K.W., Seo D.K., Bae J.Y., Ra H.J., Choi S.J., Kim J.K. Usefulness of three-dimensional computed tomography for patellofemoral measurement. *Knee Surg Sports Traumatol Arthrosc.* 2022;30(4):1423-1429. doi: 10.1007/s00167-021-06624-6.
27. Dejour D., Saggin P. The sulcus deepening trochleoplasty-the Lyon's procedure. *Int Orthop.* 2010;34(2):311-316. doi: 10.1007/s00264-009-0933-8.
28. Tecklenburg K., Dejour D., Hoser C., Fink C. Bony and cartilaginous anatomy of the patellofemoral joint. *Knee Surg Sports Traumatol Arthrosc.* 2006;14(3):235-240. doi: 10.1007/s00167-005-0683-0.
29. Hiemstra L.A., Kerslake S., Kupfer N., Lafave M. Patellofemoral Stabilization: Postoperative Redislocation and Risk Factors Following Surgery. *Orthop J Sports Med.* 2019;7(6):2325967119852627. doi: 10.1177/2325967119852627.

30. Izadpanah K., Meine H., Kubosch J., Lang G., Fuchs A., Maier D. et al. Fluoroscopic guided tunnel placement during medial patellofemoral ligament reconstruction is not accurate in patients with severe trochlear dysplasia. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(3):759-766. doi: 10.1007/s00167-019-05413-6.
31. Бур'янов О.А., Крищук М.Г., Костогриз О.А., Лиходій В.В., Єщенко В.О. Задніченко М.О. Features of structural and functional disorders in patellar instability associated with femoral condyle dysplasia (clinical and experimental study). *Trauma*. 2013;14(5):58-63. (In Ukrainian).
32. Balcarek P., Ammon J., Frosch S., Walde T.A., Schüttrumpf J.P., Ferlemann K.G. et al. Magnetic resonance imaging characteristics of the medial patellofemoral ligament lesion in acute lateral patellar dislocations considering trochlear dysplasia, patella alta, and tibial tuberosity-trochlear groove distance. *Arthroscopy*. 2010;26(7):926-935. doi: 10.1016/j.arthro.2009.11.004.
33. Conlan T., Garth W.P. Jr., Lemons J.E. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. *J Bone Joint Surg Am.* 1993;75(5):682-693. doi: 10.2106/00004623-199305000-00007.
34. Kernkamp W.A., Wang C., Li C., Hu H., van Arkel E.R.A., Nelissen R.G.H.H. et al. The Medial Patellofemoral Ligament Is a Dynamic and Anisometric Structure: An in Vivo Study on Length Changes and Isometry. *Am J Sports Med.* 2019;47(7):1645-1653. doi: 10.1177/0363546519840278.
35. Yang Y., Zhang Q. Reconstruction of the medial patellofemoral ligament and reinforcement of the medial patellotibial ligament is an effective treatment for patellofemoral instability with patella alta. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(8):2995-2907. doi: 10.1007/s00167-018-5281-z.
36. Hetsroni I., Mann G., Dolev E., Nyska M. Combined reconstruction of the medial patellofemoral and medial patellotibial ligaments: outcomes and prognostic factors. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(2): 507-515. doi: 10.1007/s00167-018-5145-6.
37. Redler L.H., Spang R.C., Tepolt F., Davis E.A., Kocher M.S. Combined reconstruction of the medial patellofemoral ligament [MPFL] and medial quadriceps tendon-femoral ligament [MQTFL] for patellar instability in children and adolescents: surgical technique and outcomes. *Orthop J Sports Med.* 2017;5(7). doi: 10.1177/ 2325967117S00387.
38. Malanin D.A., Novikov D.A., Suchilin I.A., Cheresov L.L. Significance of medial patello-femoral ligament in support of patella stability: features of anatomy and biomechanics. *Traumatology and Orthopedics of Russia.* 2015;(2):56-65. (In Russian). doi: 10.21823/2311-2905-2015-0-2-56-65.
39. Erickson B.J., Nguyen J., Gasik K., Gruber S., Brady J., Shubin Stein B.E. Isolated Medial Patellofemoral Ligament Reconstruction for Patellar Instability Regardless of Tibial Tubercle-Trochlear Groove Distance and Patellar Height: Outcomes at 1 and 2 Years. *Am J Sports Med.* 2019;47(6):1331-1337. doi: 10.1177/0363546519835800.
40. Post W.R., Fithian D.C. Patellofemoral Instability: A Consensus Statement From the AOSSM/PFF Patellofemoral Instability Workshop. *Orthop J Sports Med.* 2018;6(1):2325967117750352. doi: 10.1177/2325967117750352.
41. Schöttle P.B., Schmeling A., Rosenstiel N., Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med.* 2007;35(5):801-804. doi: 10.1177/0363546506296415.
42. Migliorini F., Driessen A., Quack V., Gatz M., Tingart M., Eschweiler J. Surgical versus conservative treatment for first patellofemoral dislocations: a meta-analysis of clinical trials. *Eur J Orthop Surg Traumatol.* 2020;30(5):771-780. doi: 10.1007/s00590-020-02638-x.
43. Schmeling A., Schöttle P. Revisionen nach MPFL rekonstruktion. *Arthroskopie*. 2015;28:202-212. doi: 10.1007/s00142-015-0028-z.
44. Neri T., Parker D.A., Putnis S., Klasan A., Trombert-Paviot B., Farizon F. et al. Clinical and Radiological Predictors of Functional Outcome After Isolated Medial Patellofemoral Ligament Reconstruction at Midterm Follow-up. *Am J Sports Med.* 2019;47(6):1338-1345. doi: 10.1177/0363546519831294.
45. Raoulis V.A., Zibis A., Chiotelli M.D., Kermanidis A.T., Banios K., Schuster P. et al. Biomechanical evaluation of three patellar fixation techniques for MPFL reconstruction: Load to failure did not differ but interference screw stabilization was stiffer than suture anchor and suture-knot fixation. *Knee Surg Sports Traumatol Arthrosc.* 2021;29(11):3697-3705. doi: 10.1007/s00167-020-06389-4.
46. Berton A., Salvatore G., Orsi A., Egan J., DeAngelis J., Ramappa A. et al. Lateral retinacular release in concordance with medial patellofemoral ligament reconstruction in patients with recurrent patellar instability: A computational model. *Knee*. 2022;39:308-318. doi: 10.1016/j.knee.2022.10.006.
47. Levy B.J., Jimenez A.E., Fitzsimmons K.P., Pace J.L. Medial patellofemoral ligament reconstruction and lateral retinacular lengthening in the skeletally immature patient. *Arthrosc Tech.* 2020;9(6):e737-e745. doi: 10.1016/j.eats.2020.02.004.
48. Patel N.K., Lesniak B.P. Editorial commentary: medial patellofemoral ligament reconstruction: are we overtensioning the graft? *Arthroscopy*. 2020;48(5):1396-1397. doi: 10.1016/j.arthro.2020.02.035.
49. Biesert M., Johansson A., Kostogiannis I., Roberts D. Self reported and performance based outcomes following medial patellofemoral ligament reconstruction indicate successful improvements in knee stability after surgery despite remaining limitations in knee function. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(3):934-940. doi: 10.1007/s00167-019-05570-8.
50. Liu J.N., Brady J.M., Kalbian I.L., Strickland S.M., Ryan C.B., Nguyen J.T. et al. Clinical Outcomes After Isolated Medial Patellofemoral Ligament Reconstruction for Patellar Instability Among Patients With Trochlear Dysplasia. *Am J Sports Med.* 2018;46(4):883-889. doi: 10.1177/0363546517745625.

51. Geierlehner A., Liebensteiner M., Schottle P., Dirisamer F. Prevailing disagreement in the treatment of complex patellar instability cases: an online expert survey of the AGA Knee–Patellofemoral Committee. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(8):2697-2705. doi: 10.1007/s00167-020-05936-3.
52. Blønd L., Schöttle P.B. The arthroscopic deepening trochleoplasty. *Knee Surg Sports Traumatol Arthrosc.* 2010;18(4):480-485. doi: 10.1007/s00167-009-0935-5.
53. Korolev A.V., Magnitskaya N.E., Ryazantsev M.S., Sinitskiy M.A., Kadantsev P.M., Afanas'yev A.P. et al. Transpatellar reconstruction of medial patellofemoral ligament by semitendinous tendon autograft. *Traumatology and Orthopedics of Russia.* 2018;24(3):91-102. (In Russian). doi: 10.21823/2311-2905-2018-24-3-91-102.
54. Shah J.N., Howard J.S., Flanigan D.C., Brophy R.H., Carey J.L., Lattermann C. A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation. *Am J Sports Med.* 2012;40(8):1916-1923. doi: 10.1177/0363546512442330.
55. Feucht M.J., Mehl J., Forkel Ph., Achtnich A., Schmitt A., Izadpanah K. et al. Failure analysis in patients with patellar redislocation after primary isolated medial patellofemoral ligament reconstruction. *Orthop J Sports Med.* 2020;8(6):2325967120926178. doi: 10.1177/2325967120926178.
56. Dejour D., Le Coultre B. Osteotomies in patello-femoral instabilities. *Sports Med Arthrosc Rev.* 2007;15(1):39-46. doi: 10.1097/JSA.0b013e31803035ae.
57. Steensen R.N., Bentley J.C., Trinh T.Q., Backes J.R., Wiltfong R.E. The prevalence and combined prevalences of anatomic factors associated with recurrent patellar dislocation: a magnetic resonance imaging study. *Am J Sports Med.* 2015;43(4):921-927. doi: 10.1177/0363546514563904.
58. Imhoff F., Funke V., Muench L.N., Sauter A., Englmaier M., Woertler R., Imhoff M.B., Feucht M.J. The complexity of bony malalignment in patellofemoral disorders: femoral and tibial torsion, trochlear dysplasia, TT–TG distance, and frontal mechanical axis correlate with each other. *Knee Surg Sports Traumatol Arthrosc.* 2020;28(3):897-900. doi: 10.1007/s00167-019-05542-y.
59. Brown D.E., Alexander A.H., Lichtman D.M. The Elmslie-Trillat procedure: evaluation in patellar dislocation and subluxation. *Am J Sports Med.* 1984;12(2):104-109. doi: 10.1177/036354658401200203.
60. Franciozi C.E., Ambra L.F., Albertoni L.J.B., Debieux P., Granata G.S.M. Jr., Kubota M.S. et al. Anteromedial Tibial Tubercle Osteotomy Improves Results of Medial Patellofemoral Ligament Reconstruction for Recurrent Patellar Instability in Patients With Tibial Tuberosity-Trochlear Groove Distance of 17 to 20 mm. *Arthroscopy.* 2019;35(2):566-574. doi: 10.1016/j.arthro.2018.10.109.
61. Jud L., Singh S., Tondelli T., Fürnstahl P., Fucentese S.F., Vlachopoulos L. Combined Correction of Tibial Torsion and Tibial Tuberosity-Trochlear Groove Distance by Supratuberositary Torsional Osteotomy of the Tibia. *Am J Sports Med.* 2020;48(9):2260-2267. doi: 10.1177/0363546520929687.
62. Arendt E.A., Askenberger M., Agel J., Tompkins M.A. Risk of redislocation after primary patellar dislocation: a clinical rediction model based on magnetic resonance imaging variables. *Am J Sports Med.* 2018;44(14): 3385-3390. doi: 10.1177/0363546518803936.
63. Hiemstra L.A., Peterson D., Youssef M., Soliman J., Banfield L., Olufemi R. et al. Trochleoplasty provides good clinical outcomes and an acceptable complication profile in both short and long-term follow-up. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(9):2967-2983. doi: 10.1007/s00167-018-5311-x.
64. Hiemstra L.A., Kerslake S., Loewen M., Lafave M. Effect of Trochlear Dysplasia on Outcomes After Isolated Soft Tissue Stabilization for Patellar Instability. *Am J Sports Med.* 2016;44(6):1515-1523. doi: 10.1177/0363546516635626.
65. Longo U., Vincenzo C., Mannuring N., Ciuffreda M., Salvatore G., Berton A. et al. Trochleoplasty techniques provide good clinical results in patients with trochlear dysplasia. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(9):2640-2658. doi: 10.1007/s00167-017-4584-9.
66. Zaffagnini S., Previtali D., Tamborini S., Pagliazzi G., Filardo G., Candrian Ch. Recurrent patellar dislocations: trochleoplasty improves the results of medial patellofemoral ligament surgery only in severe trochlear dysplasia. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(11):3599-3613. doi: 10.1007/s00167-019-05469-4.
67. Tan S.H.S., Lim B.Y., Chng K.S.J., Doshi C., Wong F.K.L., Lim A.K.S. et al. The Difference between Computed Tomography and Magnetic Resonance Imaging Measurements of Tibial Tubercle-Trochlear Groove Distance for Patients with or without Patellofemoral Instability: A Systematic Review and Meta-analysis. *J Knee Surg.* 2020;33(8):768-776. doi: 10.1055/s-0039-1688563.
68. Zhang Z., Cao Y., Song G., Li Y., Zheng T., Zhang H. Derotational femoral osteotomy for treating recurrent patellar dislocation in the presence of increased femoral anteversion: a systematic review. *Orthop J Sports Med.* 2021;9(11):23259671211057126. doi: 10.1177/23259671211057126.

Authors' information

✉ *Dmitri A. Konokotin*
Address: 6, St. Petersburg, Akademika Lebedeva st., 194044, Russia
http//orcid.org/0000-0003-3100-0321
e-mail: konokotin.dmitry@yandex.ru

Vladimir V. Khominets — Dr. Sci. (Med.), Professor
http://orcid.org/0000-0001-9391-3316
e-mail: khominets_62@mail.ru

Oleg V. Rikun — Cand. Sci. (Med.)
https://orcid.org/0000-0002-2027-8996
e-mail: rikoleg@yandex.ru

Aleksey O. Fedotov — Cand. Sci. (Med.)
https://orcid.org/0000-0002-9953-9385
e-mail: alexfedot83@gmail.com

Aleksey S. Grankin — Cand. Sci. (Med.)
https://orcid.org/0000-0002-4565-9066
e-mail: aleksey-grankin@yandex.ru

Alexandr S. Vorobyev
https://orcid.org/0009-0006-8878-0145
e-mail: aleks.vorobev2000@mail.ru