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Lateral Unicompartmental Knee Arthroplasty in Structure of Modern Knee Replacement: Is It «Woe From Wit» or a Viable Go-To Method?

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Abstract

Background. Recent studies have shown that there are no significant differences in clinical and functional outcomes between medial and lateral unicompartmental knee arthroplasty (UKA), despite the fact that historically lateral UKA has been considered a more complex procedure with less predictable results. ***Research hypothesis.*** We hypothesized that lateral UKA in patients with end-stage lateral knee osteoarthritis is an effective surgical procedure that allows obtaining good and excellent mid-term functional results, similar to those of medial UKA and better than those of total knee arthroplasty (TKA). ***Materials and Methods.*** A retrospective two-center study included 140 patients with end-stage knee osteoarthritis. From 2011 to 2018, they underwent knee arthroplasty at Vreden National Medical Research Center of Traumatology and Orthopedics, Saint Petersburg, Russia, or Federal Center of Traumatology, Orthopedics and Arthroplasty, Cheboksary, Russia. Group I (the main group) consisted of 15 patients with Krackow I knee valgus deformity who received lateral UKA using the Journey Uni implant (Smith & Nephew, UK) with a constrained all-polyethylene tibial component. Group II included 58 end-stage knee osteoarthritis patients with predominant involvement of the medial compartment who underwent medial UKA with the endoprosthesis of a similar design. Group III consisted of 67 patients with knee osteoarthritis accompanied by Krackow type II knee valgus deformity who underwent TKA with retention of the posterior cruciate ligament. The studied groups were compared for the achieved range of motion in the operated joint, its functional state (Oxford Knee Score, OKS, and Forgotten Joint Score, FJS), as well as for the rate and type of complications. ***Results.*** The present study had two objectives. The first objective was to compare the outcomes of lateral and medial UKA. It was revealed that lateral UKA allowed obtaining a good function of the operated knee with higher FJS values. The second objective was to analyze the results of lateral UKA and TKA in patients with a valgus knee deformity. In this regard, our study revealed that the UKA group in comparison with the TKA group had higher FJS values (71.5±5.3 vs 65.2±7; p=0.9) and a slightly lower range of motion in the knee according to OKS (34.6±2.3 vs 35.9±2.2; p=0.7). However, for both scores, the differences were not statistically significant. ***Conclusion.*** Despite the fact that lateral UKA allowed achieving good functional outcomes, the integral score in this group of patients was not significantly different from that of patients after medial UKA and TKA. Our study demonstrated that patients' satisfaction was strongly correlated with age and body mass index in the UKA group, while in the TKA group, a similar relationship was found only between FJS values and body mass index.

Keywords: total knee arthroplasty, unicompartmental knee arthroplasty, knee osteoarthritis, valgus, varus.

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Despite the increase in the availability of high-tech orthopedic care in the modern world, the number of patients with knee osteoarthritis (KO) does not decrease over time, and because of the awareness of the population, even more people consult orthopedists seeking surgical interventions [1]. Due to its high efficacy, total knee arthroplasty (TKA) has been playing a leading role in treating advanced KO for more than four decades. However, both orthopedic surgeons and their patients should keep in mind that one of the most serious limitations of this procedure is the fact that patients' expectations and their claims turn out to be much higher than the capabilities of TKA [2, 3, 4]. In addition, KO morbidity patterns are characterized by an increase in the number of young, physically and socially active patients with unilateral involvement (predominant lesion of the medial or lateral part of the joint). Their expectations from a surgical intervention include not only pain relief, but also returning to the lost high level of physical activity, which is directly associated with the quality of life in their perceptions. For this category of patients, partial or unicompartmental knee arthroplasty (UKA) can represent an adequate alternative to TKA. This procedure allows for better preserving of physiological kinematics, minimizing the bone and soft tissue traumatization during the intervention, and, consequently, obtaining higher functional results [5].

Main indications for UKA include II-III degree KO with predominant involvement of the medial compartment and a varus deformity of the lower limb, or with more pronounced pathology of the lateral compartment and a valgus deformity of the lower limb [6, 7]. Many authors agree that UKA is a highly effective type of surgical interventions for unilateral KO. The advantages of UKA in comparison with TKA include minimizing intraoperative soft tissue traumatization, a lower level of perioperative blood loss, and a greater range of motion postoperatively that allows restoring the kinematics of the knee close to its native state [8, 9].

Degenerative-dystrophic lesions of the medial knee compartment with a varus deformity of the limb represent the most prevalent type of unilateral KO. KO with a valgus deformity is much less prevalent accounting for only 10-15% of cases of KO [10, 11, 12]. When assessing this group of patients one should keep in mind that lateral KO often has a posttraumatic origin (resulting from injuries of the lateral meniscus, fractures of the lateral tibial or femoral condyle), and, less often, in contrast to medial KO, it appears to be idiopathic [13, 14, 15]. The significance of posttraumatic etiology of lateral KO is also confirmed by the rate of tibial plateau fractures among all intraarticular fractures of the lower extremities (10%), of which 90% are the fractures of the lateral condyle [15, 16].

It is difficult to assess the efficacy of lateral UKA because of the small number of patients with KO associated with a valgus deformity for whom orthopedic surgeons choose this type of intervention. According to foreign literature data, lateral UKA is performed only in 1% of patients undergoing knee arthroplasty [17]. The limitations for this type of interventions include the small number of relevant patients in the population of individuals with KO, possible technical difficulties, accompanying perioperative risks, and the cautious attitude of orthopedic surgeons to this procedure, which is much less developed than TKA. Moreover, the difficulties of treating patients with lateral KO are also associated with specific features of the valgus deformities that imply complex soft tissue balancing and increased risk of the need for constrained structures or special surgical techniques during the intervention [10, 18].

We were unable to find any national epidemiological data regarding lateral UKA. This fact confirms the low "popularity" of this type of surgical interventions among Russian specialists, which is, however, consistent with the global trend.

At the same time, recent foreign studies have shown that there are no significant differences in clinical and functional outcomes between medial and lateral UKA, despite the fact that lateral UKA has been historically considered a more complex type of intervention with less predictable results as compared to TKA [19, 20]. Our interest in the objective assessment of the position of lateral UKA in the modern model of orthopedic care for patients with KO in Russia and worldwide prompted us to perform the present study.

Research hypothesis: We hypothesized that lateral UKA in patients with end-stage lateral knee osteoarthritis is an effective surgical procedure that allows obtaining good and excellent mid-term functional results, similar to those of medial UKA and better than those of TKA.

Materials and Methods

Study design

This was a retrospective two-center cohort study. The study included 140 patients with deforming KO who underwent knee arthroplasty from 2011 to 2018 at Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia, and at Federal Center of Traumatology, Orthopedics and Arthroplasty, Cheboksary, Russia.

Group I (the main group) consisted of 15 patients with KO associated with Krackow I valgus deformity [12]. They underwent lateral UKA using the Journey Uni system (Smith & Nephew, UK) with a constrained all-polyethylene tibial component.

Group II included 58 KO patients with predominant involvement of the medial compartment who underwent medial UKA with the endoprosthesis of a similar design.

Group III consisted of 67 patients with KO accompanied by Krackow type II knee valgus deformity [12] who underwent TKA with retention of the posterior cruciate ligament.

The main inclusion criteria were clinical and radiological signs of KO resistant to conservative treatment with predominant involvement of the lateral or medial part of the joint. We did not set any restrictions related to body mass index, gender, and age. The final quantitative composition of the compared groups was determined by the availability of patients for follow-up with the assessment of the mid-term clinical and functional results of the surgical intervention.

We excluded 37 patients who were not available for questioning or examination in the follow-up period (Fig. 1).

The distribution of included patients by sex, age, and body mass index is shown in Table 1.

Assessment of the results

The studied groups were compared based on the following parameters: the range of motion in the operated knee after the procedure, the functional state of the knee according to the Oxford Knee Score (OKS) [21] and Forgotten Joint Score (FJS) [22] questionnaires after the procedure, the rates and types of complications.

The mean postoperative follow-up period amounted to 4 years (Me 4 years, SD 1.5 years); the minimum period was 12 months.

Diagnostic methods

Clinical examination of the knee. Before the operation, the patients were assessed for lameness severity, the need for walking aids, the severity of the lower limb deformity at the level of the knee in the frontal and sagittal planes, passive and active range of motion, the degree of frontal and sagittal ligamentous instability, the presence of a contracture and its type. We considered the possibility of passive correction of the frontal deformity as one of the key points since it was indicative of the rigidity of the ligamentous complex on the affected side and the extent of hypermobility and overstretching of the contralateral part of the knee. In case of doubts, when radiographs did not allow performing a full assessment of the knee condition, MRI was used.

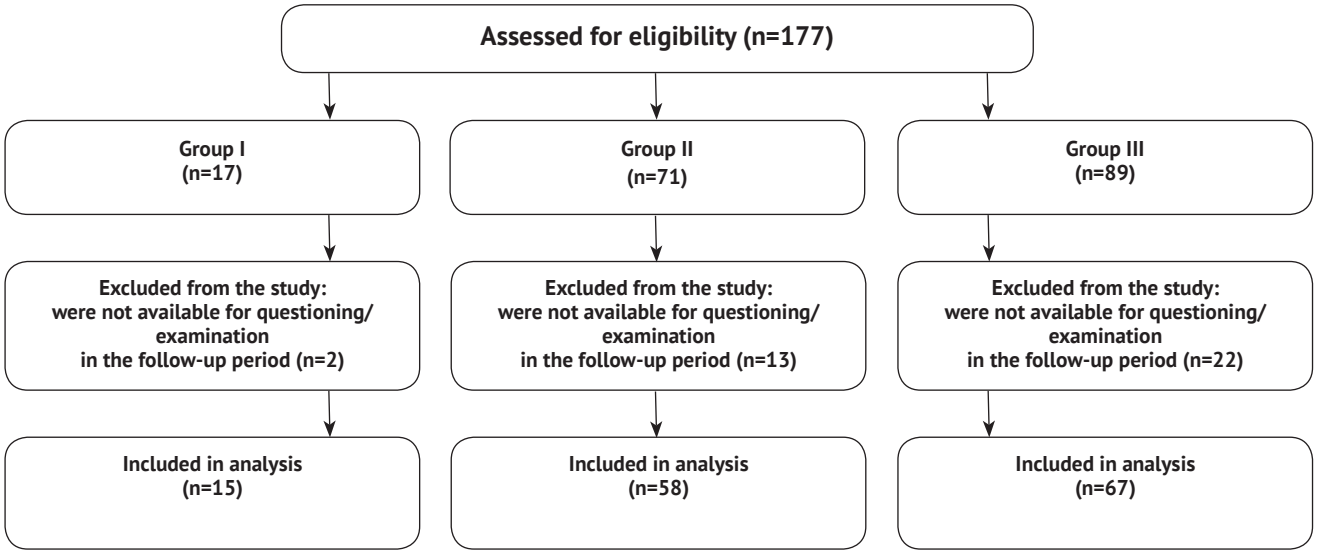

Figure 1. The study flowchart

Table 1

Characteristics of patients included in the study

Parameters	Group			p
	I	II	III	
Sex, % female male	93.3 6.7	80 20	85 15	1
Age, years	58.3±4.0 (Me 59)	68±5 (Me 67)	60±5 (Me 61)	0.1
Body mass index	30.8±2.0 (Me 30)	30.4±2 (Me 31)	28.7±1.5 (Me 29)	1.1

X-ray examination. To clarify the indications for arthroplasty before the operation and to assess the spatial position of the components and the quality of their fixation after the operation we used two-views radiographs in the supine position, anteroposterior weight-bearing radiographs in the standing position with 20° to 30° of knee flexion and teleradiographs of both lower extremities. The stage of KO, the pattern of the knee bones destructive changes, the severity of the frontal deformity of the limb and its center of rotation of angulation (CORA) were assessed radiographically [23].

Anesthesia and prevention of thromboembolism

All patients underwent spinal anesthesia with intravenous sedation. Tranexamic acid at the dose of 1.5 g was administered intravenously 30 minutes before the operation to all patients. All patients were subjected to the same prophylaxis regimen for thromboembolism prevention. They were injected with low molecular weight heparin 12 hours before the operation. The dosage was selected taking into account patients' age, weight and comorbidities. Class 1 elastic compression stockings were used during the postoperative period. Low molecular weight heparin was administered subcutaneously to all patients throughout the postoperative period with converting to oral anticoagulants on Day 21.

Characteristics of surgical approach

All patients were operated in the supine position with the operated lower limb fixed by an orthopedic table holder. A pneumatic

tourniquet with a cuff pressure of 270 to 300 mm Hg was used during the operation in all patients.

Group I patients underwent the anterolateral knee minimally invasive approach. A 7-10 cm skin incision was performed along the edge of the patella from its upper edge to the lateral surface of the tibial tuberosity. The lateral arthrotomy was performed within the same limits.

Group II patients underwent the anteromedial minimally invasive approach to the knee. A 7-10 cm skin incision was performed along the edge of the patella from its upper point to the medial surface of the tibial tuberosity. The medial parapatellar arthrotomy was performed within the same limits. The employed surgical approach was conceptually close to the technique developed by J. Goodfellow et al. [24].

In group III, all patients underwent the anterolateral approach to the knee. The soft tissue release stages were performed in accordance with the technique by P. Keblish [25].

Postoperative management and rehabilitation programs were identical for patients in both groups. External immobilization (with plaster casts, splints, or hinged braces) was not used. The patients began to walk with the aid of crutches from the first day after the operation. Restoration of the knee motion was performed taking into account a patient's pain threshold.

Statistical analysis

After obtaining data of all patients included in the study we created an electronic data set using Microsoft Excel software. Statistical data processing was performed using the Past 3.17 software (2017). Nonparametric Wilcoxon-Mann-Whitney and Kolmogorov-Smirnov tests were used for statistical analysis. The standard deviation (SD) values were calculated for all studied parameters. Correlation analysis was performed using Spearman's rank correlation test.

Results

The present study had two objectives. The first objective was to compare the outcomes of lateral and medial UKA performed with one type of endoprosthesis placement and one instrumental system. The second objective was to analyze the results of lateral UKA and TKA in patients with a valgus knee deformity.

Comparison of the outcomes showed that lateral UKA allowed obtaining a good function of the operated knee with higher FJS values as compared to medial UKA, although the difference was not statistically significant (Table 2). Meanwhile, patients in the lateral UKA group had lower OKS values for the operated knee function, but the difference was not statistically significant as well. A higher number of complications (in absolute values) was observed in patients who underwent medial UKA (Table 3).

The intensity of pain in one patient (3.3%) from group II led to the need for conversion (revision TKA). In group I, the revision arthroplasty was required in two cases (13.3%) due to aseptic loosening of the endoprosthesis tibial component. According to the correlation analysis, satisfaction with the results of the performed intervention was directly linked to the patients' age and body mass index both in the lateral and medial UKA groups (Table 4).

Table 2

Functional outcomes in groups I and II according to FJS and OKS scores

Score	Group		Mann-Whitney test	Kruskal-Wallis test
	I	II		
FJS	71.5±5.3 (Me 70.2)	64.4±8.2 (Me 66.6)	0.9	0.1
OKS	34.6±2.3 (Me 35)	35±2.4 (Me 35)	0.7	0.9

Table 3

The rate of complications in groups I and II (the first study objective)

Complications	Group		p
	I	II	
Knee contracture (stiffness): extension greater than 0° and flexion less than 110° (0° to 110°)	1 (6.6%)	4 (13.3%)	0.08
Chronic pain syndrome	–	2 (6.6%)	–
Aseptic loosening of the endoprosthesis tibial component	2 (13.3%)	–	–

Table 4

Correlations of clinical characteristics with OKS and FJS scores in groups I and II (the first study objective)

Parameters		Spearman's correlation coefficients	
		Group I	Group II
OKS	Age	0.7	0.2
	Body mass index	0.6	0.2
FJS	Age	0.7	0.4
	Body mass index	0.7	0.4

With regard to the second objective of the study, it was found that the majority of patients showed good functional results after the intervention both in the UKA and TKA groups (Table 5). A higher mean value of FJS was observed in the UKA group, while the range of motion of the knee according to OKS in these patients was lower than in those after TKA (in absolute values, without statistically significant differences).

A higher number of complications (in absolute values) was observed in patients who underwent TKA (Table 6). The overall complication rate in groups I and III was equal (19.9% each). Aseptic loosening of the endoprosthesis tibial component was detected in two cases (13.3%) after UKA and was not detected in the TKA group by the end of follow-up.

Comparison of groups I and III revealed that the UKA group was characterized by strong correlations between patients' satisfaction with the results of the performed intervention and the increase in age and body mass index. In the TKA group, a similar strong correlation was found only between body mass index and functional outcomes according to FJS (Table 7).

Table 5

Functional outcomes in groups I and III according to FJS and OKS scores

Score	Group		Mann-Whitney test	Kruskal-Wallis test
	I	III		
FJS	71.5±5.3 (Me 70.2)	65.2±7 (Me 66)	0.9	0.1
OKS	34.6±2.3 (Me 35)	35.9±2.2 (Me 35)	0.7	0.9

Table 6

The rate of complications in groups I and III (the second study objective)

Complications	Group		p
	I	III	
Knee contracture (stiffness): extension greater than 0° and flexion less than 110° (0° to 110°)	1 (6.6%)	5 (16.6%)	0.09
Chronic pain syndrome	–	1 (3.3%)	–
Aseptic loosening of the endoprosthesis tibial component	2 (13.3%)	–	–

Table 7

Correlations of clinical characteristics with OKS and FJS scores in groups I and III (the second study objective)

Parameters		Spearman's correlation coefficients	
		Group I	Group III
OKS	Age	0.7	0.4
	Body mass index	0.6	0.4
FJS	Age	0.7	0.4
	Body mass index	0.7	0.7

Discussion

Comparing the evaluated parameters in all studied groups in accordance with two study objectives we can conclude that patients achieved better functional outcomes after lateral UKA than after medial UKA or TKA as assessed by FJS (although, in general, without high values). However, it should be admitted that the majority of patients included in the study had high functional postoperative results after both UKA and TKA. With regard to the range of knee motion both lateral and medial UKA did not show significant advantages as compared to TKA. Meanwhile, traditionally, a greater range of motion in the knee was one of the primary criteria popularizing UKA as the method of choice for patients with high postoperative expectations.

Starting our study, we adhered to a steady positive image, since most authors agree that UKA allows achieving higher satisfaction with the results of the intervention and restoration of the knee function [26]. It should be noted that this belief is applicable for both medial and lateral UKA [27] irrespective of the type of the endoprosthesis used (with a mobile or constrained platform, an all-polyethylene or metal-backed tibial component) [28, 29, 30].

Our hypothesis was only partially confirmed because the obtained data were contradictory. Despite higher FJS values in the lateral UKA group, OKS values in the same group were the lowest as compared to the remaining groups. The differences were obvious only when assessing the absolute values. However, no statistically significant differences between the groups were found. Conducting a literature search on this issue, we tried to identify possible underlying reasons and to understand whether our results were so very much different from the global data.

Selection criteria for UKA

According to the literature data, clinical results of medial and lateral UKA are compa-

rable. However, most authors note that in order to achieve good results it is necessary to comply with patient selection criteria and to be careful in terms of alignment of the limb axis and correct positioning of the endoprosthesis components [19]. Kozinn-Scott criteria may be useful for adequate selection of patients for UKA. Despite the recent significant liberalization of these criteria, they remain one of the most commonly used tools [31].

The classic indications for an "ideal" UKA procedure are as follows: age >60 years at the time of the intervention, weight <82 kg, no need to perform hard physical labor, knee impairment limited to only one of its compartments, and, as the main subjective indicator, the pain associated with motion and localized only in one compartment. One of the main preoperatively detected signs is the possibility of passive correction of the frontal deformity at the level of the knee. The acceptable degree of varus or valgus deformities should not exceed 15°. In addition, the intact anterior cruciate ligament is required for effective long-term functioning of a unicompartmental endoprosthesis irrespective of the used system [19, 32].

Currently, the above-mentioned Cozinn-Scott criteria are being discussed. Some authors tried to expand them to include patients under the age of 60 in their studies. They obtained good endoprosthesis survival rates and higher functional results in comparison with those reported in earlier studies [32]. According to the results of our study, older age was associated with higher satisfaction of patients who underwent UKA, both medial and lateral. This was confirmed by strong correlations between patients' age and good functional results. In addition, despite improvements in the technologies of production and placement of modern unicompartmental endoprostheses, the revision rate in young patients remains high [26, 33]. Thus, we can observe a kind of dissonance. Orthopedists seek to choose UKA for patients with higher levels of physical activity who want to return to sport and have higher demands to the functional results of an operation. However, in the end, we see that partial knee arthroplasty is, primarily, a solution for elderly patients, in whom both implant survival and satisfaction are significantly higher than in younger individuals [34].

Despite this fact, young and active patients who undergo UKA still expect to restore a high level of activity after the intervention [35]. Several recent studies with an average follow-up of about 3 years have shown that most of the operated patients are able to return to sports and active life after the intervention, namely almost 100% after medial and about 98% after lateral UKA [32, 33, 36]. However, it should be noted that this might result not only from the unusually high efficacy of the performed procedure but also from the high-quality selection of patients who have such a high level of functional demands that they are able to return to regular sports after the intervention.

Among the selection criteria, high values of body mass index are traditionally considered a negative factor that can increase the rate of complications and the need for revisions [33, 37, 38]. Despite this fact, a number of authors do not consider obesity a contraindication to UKA and do not find any differences in outcomes between the groups of obese patients and patients with normal body weight [38]. Our data confirm that patients with higher body mass index in both the lateral and medial UKA groups have the highest level of satisfaction with the functional results of the intervention.

With regard to the correction of frontal deformities during UKA, a number of authors agree that hypocorrection improves functional outcomes [39, 40]. In order to prevent overload of the medial compartment, a residual valgus deformity after lateral UKA should be within the limit between 5° and 7° according to J. P. van der List et al. or 3° to 7° according to T. Ohdera et al. [40, 41]. Another group of researchers suggests that functional

outcomes of medial UKA are less sensitive to overcorrection of the limb axis, but with neutral alignment (up to 3° of the initial varus deformity), the patients reported a more natural feeling knee [42]. M. Vasso et al. suggest that in case of varus deformities alignment of the limb axis from 2º to 4º should provide higher functional results [43].

Thus, according to recent studies, compliance with the indications and delicate correction of the limb axis deviation are essential factors for obtaining good results after UKA.

The analysis of data obtained in the present study showed that over a relatively short period of time (up to 5 years that corresponds to mid-term outcomes), 2 patients from the lateral UKA group and 3 patients from the medial UKA group underwent revision (conversion to TKA). This obviously requires further analysis for working out a more thorough approach to the selection of patients for UKA.

Discussion of the first study objective

Direct comparisons between lateral and medial UKA are complicated by the above-mentioned fact that, among patients undergoing UKA, the knee valgus deformity is much less common than the varus deformity. Consequently, the ratio of performed lateral to medial UKA interventions equals 1:10 [17]. In addition, the anatomical and physiological differences between the lateral and medial compartments of the knee have a significant impact on the UKA technique, making it a more technically complex and less reproducible intervention. The most important anatomical features of the lateral knee, in our opinion, are as follows: an almost flat surface of the tibial lateral condyle with a neutral or negative slope, in contrast to the concave medial condyle with a pronounced sagittal posterior slope; predominantly dynamic stability of the lateral condyle provided by lateral soft tissue stabilizers, as opposed to static medial condyle stabilizers [44, 45]. It is this excessive mobility of the lateral region in flexion and in the middle position that represents a risk factor for dislocation of the meniscal insertion in patients with mobile-bearing lateral UKA [46].

The key differences lie in the biomechanics of the lateral and medial knee compartments. Displacement of the lateral meniscus during flexion-extension and rotation is two times greater (11 to 12 mm) as compared to the medial meniscus (5 to 6 mm). In deep flexion (>120°), the lateral femoral condyle rolls over the posterior edge of the plateau along with the posterior horn of the lateral meniscus, while the posterior displacement of the medial meniscus stops at 90° flexion, and both the medial femoral condyle and medial meniscus remain on the superior surface of the plateau. The presence of a so-called “screw-home” mechanism in the lateral compartment stabilizes the knee joint in full extension [44].

Given all the above considerations, surgical management of patients with KO accompanied by a valgus deformity of the limb cannot always be performed using trivial surgical options. Such interventions often require the placement of associated structures and are referred to as “complex primary knee arthroplasty” [10, 18, 47, 48].

Even the issue of the choice of a surgical approach for UKA in patients with lateral KO remains controversial. The use of a standard medial parapatellar approach to the knee for lateral UKA is more traumatic and can result in medial meniscus injury, greater blood loss, and significant soft tissue traumatization. According to T. A. Edmiston et al., patients' satisfaction with the results of lateral UKA was higher in individuals with the medial parapatellar approach than in those with the lateral approach [49]. In addition, some researchers suggest that the formation of a skin scar with a more "appropriate" location is one of the potential advantages of using the standard approach to the knee for lateral UKA since this can be important for further conversion to TKA during revision [50]. It is

also important that the medial arthrotomy provides a more typical visualization of the knee for a surgeon allowing for better orientation in a difficult clinical situation.

Due to the anatomical features of the lateral knee and potential risks of lateral UKA, mobile-bearing prostheses are used less often than fixed-bearing ones [51]. However, many studies have shown that the prostheses with mobile inserts (for the medial knee compartment) are more adapted to the biomechanics of the healthy knee [52]. This is probably due to the kinematics of the meniscus insert: during flexion, it is displaced posteriorly, and during extension – anteriorly. This allows for increasing the contact between the insert and the femoral component, reduces the wear of polyethylene, and decreases the risk of aseptic loosening of the tibial component [24]. Despite the fact that a number of authors have not found significant differences in the survival rate of various models of UKA prostheses, it has been noted that mobile-bearing UKA is associated with a higher risk of dislocation in the early postoperative period, while fixed-bearing UKA more often requires revisions due to its wear in the long term [53].

The most common complications of UKA are aseptic loosening, progression of KO into the adjacent parts of the knee, dislocation of the mobile insert, infections, instability, unexplained pain after the intervention, periprosthetic fractures, and polyethylene liner wear [54, 55]. J.A. Epinette et al. analyzed 418 unsuccessful UKA procedures in a retrospective multicenter study and found that aseptic loosening of the tibial component was observed more often and developed much earlier (37.7% within 2 years) as compared to the femoral component. According to this study, aseptic loosening was much more common in patients after medial UKA than in those after TKA. The results of our study are consistent with the literature data regarding the early aseptic loosening of the tibial component, although both cases identified in our work developed in the lateral UKA group [56].

According to our data, chronic pain was observed only in the medial UKA group, in 6.6% of cases. In one of these patients in the medial UKA group, the pain led to conversion to TKA. A study based on the National Registry of England and Wales data also found a higher revision rate due to unexplained pain after UKA compared with TKA [57]. The authors explained these findings by the fact that the revision after UKA was easier than after TKA. Therefore, in the latter case, both doctors and patients seek a more balanced decision. In addition, inexperienced surgeons often see the cause of the pain in the contralateral knee compartment, even if it is not confirmed by X-ray or MRI data. Consequently, this can lead to an unnecessary revision intervention.

M.J. Johnson and M.R. Mahfouz argued that due to the anatomical and kinematic differences between the medial and lateral knee compartments, the reasons for unsuccessful outcomes of the UKA could not be considered taken together. According to these authors, it would be more informative to analyze the complications of these types of interventions separately for each localization [55]. Recent systematic reviews showed that the reasons for revisions after medial and lateral UKA were different [34, 54]. The most common reason for revisions after medial UKA was aseptic loosening (36%), followed by the progression of KO (20%). Aseptic loosening was the most frequent cause of revisions in the early postoperative period (26%), while the progression of KO was more often observed in the mid and long terms (38% and 40%, respectively). Polyethylene liner wear and component instability were more common in the case of using the implants with constrained inserts, while unexplained pain and dislocation of the mobile insert were more common when mobile systems were employed [58, 59].

According to cohort studies, among the causes of conversion in patients with lateral UKA, the KO progression was the most frequent one (29%), followed by aseptic loosening (23%) and dislocation of mobile inserts

(10%). The KO progression rate amounted to 36%, dislocation of the endoprosthesis insert – to 17%, aseptic loosening – to 16%. According to the analysis of the registers, aseptic loosening was detected in 28% of cases, KO progression – in 24%, insert dislocation – in 5% [54]. This difference can be explained by the fact that cohort studies report the results of specialized medical centers with extensive experience, while the registers consider the data from all medical facilities, including those with very low rates of performing such interventions. Our results with regard to the reasons for revisions in group I are in line with global data.

T.R. Liebs and W. Herzberg assessed patients' quality of life after UKA and concluded that patients after lateral UKA had lower health indicators than those after medial UKA: WOMAC functional score – 34 vs 23 ($p = 0.03$), WOMAC pain score – 34 vs 21 ($p = 0.003$), physical functioning according to SF-36 survey – 38 vs 41 ($p = 0.044$) [27].

D. Saragaglia et al. reported lower functional results of lateral UKA as compared to medial UKA. According to their findings, the mean OKS was 18 ± 5 for lateral UKA and 21 ± 8 for medial UKA [60]. Our data, on the contrary, showed that lateral UKA allowed patients to obtain not only a good function of the operated joint but also higher FJS values as compared to medial UKA (71.5 ± 5.3 vs 64.4 ± 8.2 and 63.5 ± 6.1), with insignificantly lower values of the knee range of motion according to OKS (34.6 ± 2.3 vs 35 ± 2.4 and 35 ± 2.2).

J.P. van der List et al. obtained results that were close to the results of our study. They evaluated functional outcomes of UKA based on two years follow-up and reported good results for both medial and lateral UKA: WOMAC score – 89.8 ± 11.7 and 90.2 ± 12.4 ($p = 0.855$), FJS – 71.2 ± 24.5 and 70.9 ± 28, respectively ($p = 0.956$) [42].

Thus, neither global data nor the results obtained in our study allow revealing objective differences in clinical and functional outcomes of medial and lateral UKA, despite conceptual differences between these surgical interventions.

Discussion of the second study objective

With regard to the comparison of the outcomes of lateral UKA and TKA, it should be noted that lateral UKA has some technical aspects that can be called critical rather than just important. In particular, only in the case of preserving the knee natural biomechanics during the intervention, it is possible to expect the benefits of this operation as compared to the standard TKA.

Our study revealed that the UKA group was characterized by higher FJS values than the TKA group (71.5 ± 5.3 vs 65.2 ± 7.0), although the differences were not statistically significant. Meanwhile, patients with lateral UKA had insignificantly lower knee range of motion as assessed by OKS (34.6 ± 2.3 vs. 35.9 ± 2.2, respectively).

According to T. Walker et al., lateral UKA allows for achieving better functional results in comparison with TKA [61]. The mean follow-up period in their study amounted to 19-22 months. Patients after lateral UKA had significantly higher values of OKS (14.3 ± 6.0 vs 9.6 ± 8.0) and the range of motion (12 ± 19° vs –3° ± 20°). 2-year survival (assessed as the absence of revision for any reason) was 96% (95% CI 72-99) for UKA and 100% for TKA [62].

Other researchers also reported satisfactory clinical outcomes of lateral UKA in both idiopathic and post-traumatic KO [13, 63, 64].

T. Walker et al. demonstrated that lateral UKA in relatively young patients allowed obtaining good functional outcomes and returning to sports. Their data showed that up to 98% of these patients returned to full-fledged life without any limitations associated with the operation, and 2/3 of them achieved a high level of physical activity, including sports [65]. Similar results were obtained by S. Lustig et al. who reported that UKA could relieve pain and restore function

in relatively young patients with post-traumatic lateral KO [13]. At the same time, other authors found that patients after TKA demonstrated similar functional results and the rate of returning to sports [66].

On the contrary, N. G. Weiss et al. analyzed a series of 62 patients with a mean follow-up of 4.2 years (mean patients' age 46 years) after TKA for post-traumatic KO with tibial plateau fracture and found that the mean KSS score was 82.9 with a number of perioperative (10%) and postoperative (26%) complications and a total revision rate of up to 21% in the first 5 years after the intervention [67].

In conclusion, the published data regarding UKA and TKA are contradictory. It is impossible to single out clear advantages of one of these types of interventions for patients with isolated lateral KO. The analysis of the literature data and our own results indicate that lateral UKA, as compared to TKA, is an acceptable option for isolated KO. It is less invasive, although technically more complex, and is associated with good recovery of the knee function in the postoperative period, but without significant advantages. On the one hand, UKA allows the majority of active patients to return to physical exercises and sports. On the other hand, recent meta-analyses directly indicate that UKA is the method of choice for older patients because extremely high levels of physical activity can be among the causes for early revisions.

Study limitation

It can be concluded that, due to the limited number of observations in the main group, it is necessary to analyze more patients after lateral UKA and to assess the long-term outcomes of this type of interventions. Most studies evaluating the outcomes of lateral UKA, including ours, represent small case series. This circumstance is the most serious, but difficult to correct, limitation associated with the following factors: the small share of eligible patients in the population of individuals with KO, insufficient awareness of orthopedic surgeons about this type of operations, and its low "popularity".

Regarding the study design, it would be better to assess the differences in outcomes of lateral and medial UKA separately in patients with constrained and mobile platforms. However, due to the high risk of dislocation of the mobile insert after lateral UKA, it was decided to refrain from recruiting this group of patients despite the fact that scientific literature contains some encouraging data on the successful use of this technique.

Publication Ethics

All patients gave their voluntary written informed consent for participation in the study.

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Authors' contributions

D.V. Chugaev – study design, literature data collection and analysis, text preparation.

N.N. Kornilov – study design, text editing.

A.S. Karpukhin – data collection, text editing.

P.G. Kogan – text editing.

S.A. Lasunsky – study design, participation in the clinical part of the study.

All authors made a significant contribution to the research and preparation of the article and read and approved the final version before its publication. They agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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