DOI 10.18019/1028-4427-2017-23-3-314-322

Efficiency and safety of sliding osteotomy of the lateral femoral condyle in total knee arthroplasty in patients with fixed valgus deformity (Krackow type III)

D.V. Stafeev, D.V. Chugaev, S.A. Lasunsky, N.N. Korniliv, A.D. Sineoky

Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia

Introduction This article is devoted to the problem of total knee arthroplasty in patients with severe valgus deformity (Krackow type III). **Methods** We analyzed mid-term results of 12 total knee arthroplasties combined with sliding osteotomy of the lateral femoral condyle and distalization of the lateral collateral ligament. Treatment results were measured with KSS and WOMAC scores. **Results** We had excellent and good results in 11 cases but one was complicated with periprosthetic fracture of the femur. **Discussion** Up-to-date, there are various techniques proposed for soft-tissue release in total knee arthroplasty. These techniques differ in the point of release and the power of effect. However, an adequate balance is not always achievable in severe valgus deformity. Therefore, implants providing enhanced frontal stabilization are required (CCK/VVC).

Keywords: knee joint arthroplasty, valgus deformity, Krackow classification, soft-tissue release, instability, sliding osteotomy, complex arthroplasty

INTRODUCTION

Deforming osteoarthritis of the knee joint (gonarthrosis), in addition to persistent pain and contracture, is usually accompanied by frontal varus or valgus deformity [1]. Statistically, valgus deformity at the level of the knee joint is much less frequent than varus, and its frequency ranges within 10 to 15 % in the general population of patients undergoing total knee arthroplasty [2].

Valgus symptoms are mechanical axis deviation of the limb, angled outwards from the center of the knee joint, and an increased valgus angle between the femur and tibia for more than 9º [3, 4]. In 5 to 30 % of patients with knee osteoarthritis deformans, valgus is referred to Krackow type III: fixed deformity accompanied by severe frontal instability. It presents difficulty for surgical correction during the arthroplasty procedure [5, 6]. This involves considerable destructive changes of the epiphyses of the femur and tibia, lateral contraction of the "valgus" knee capsule, ilio-tibial tract, lateral collateral ligament, popliteal muscle and its tendons, and a combination of intra- and extra-articular components of the anterior lower limb deformity [7].

Surgery in such patients can be associated with significant difficulties. Along with adequate selection of implant component sizes, elimination of contractures and proper tracking of the patella during knee replacement surgery, one of the most important conditions is to provide the proper biomechanical axis of the lower limb and to form isometric and symmetrical rectangular flexion and extensor gaps [8].

A complex combination of pathological changes in the "valgus knee" does not allow a clear soft-tissue release algorithm which is applicable for osteoarthritis with varus limb deformity. The above changes, inherent to the "valgus knee", can make successful arthroplasty difficult to achieve [9]. Only an adequate filing of the bone epiphyses forming the knee joint is not enough to recreate the correct biomechanical axis of the limb. It is also necessary to perform soft-tissue release of the contracted lateral compartment of the knee joint. Therefore, the higher is the degree of rigidity of the lateral department and frontal instability, the more difficult it is to achieve adequate balancing of the knee joint and the more likely is the use of the implant stabilized in the frontal plane or constrained prosthesis [10]. In this case, an extensive soft tissue release may also be ineffective and result in the implantation of CCK/VVC prosthesis [11].

🕮 Stafeev D.V., Chugaev D.V., Lasunsky S.A., Korniliv N.N., Sineoky A.D. Efficiency and safety of sliding osteotomy of the lateral femoral condyle in total knee arthroplasty in patients with fixed valgus deformity (Krackow type III). *Genij Ortopedii*. 2017. T. 23. No 3. pp. 314-322. DOI 10.18019/1028-4427-2017-23-3-314-322. (In Russian)

The extra-articular valgus deformity component also contributes to this situations and has to be corrected using bone sawlines to increase the trapezoidal flexion/extension gaps. The presence of a constitutional varus deformity of the diaphysis or valgus deformity of the distal femur and valgus deformity of the proximal tibia that aggravate the existing valgus deformity of the limb at the level of the knee joint leads to the condition in which it is necessary to carry out an extended release even if the soft tissue stabilizers are not contracted. It may cause a complete frontal destabilization of the knee joint [12].

An alternative to the use of constrained implants and extensive "extreme soft tissues release" to correct valgus deformity of type III according to Krackow is a sliding osteotomy of the lateral femoral condyle with distalization of the attachment site of the lateral collateral ligament and the tendon of the popliteal muscle.

The following hypothesis was put forward in implementation of this study: since the fixed valgus deformity of type III according to Krackow has an extra-articular component, its correction due to extensive release of soft tissues can fail as it has no effect on the pathogenetic focus of the deformity. In this regard, after stages I and II of the soft tissue release and leaving the lateral collateral ligament and the tendon of the popliteal muscle intact, a sliding osteotomy of the lateral femoral condyle with transposition of the fixation point of the lateral stabilizers was performed. This manipulation, according to the hypothesis of the study, was to provide a balance of the flexion/extension gaps of the knee joint by changing the length of the lateral collateral ligament and the popliteal tendon to a precise amount in the absence of an extended soft tissue release. This approach, in our opinion, was to make an operation of knee arthroplasty in a fixed valgus deformity of type III according to Krackow more predictable.

Purpose To study the efficacy (reconstruction of the neutral limb axis, formation of symmetric flexion/extension gaps, restoration of adequate patellar tracking) of the proposed correction procedure for fixed valgus deformity of Krackow type III in knee replacement and to follow up the recovery level of patients' functional activity in the postoperative period.

MATERIAL AND METHODS

This prospective study included 10 patients with deforming osteoarthritis and valgus deformity of the knee joint of type III according to Krackow who underwent 12 arthroplasty operations combined with a sliding osteotomy of the lateral femoral condyle and a transposition of the fixation point of the lateral ligamentous structures in the period from 2011 to 2015.

Nine were women and one was male. The mean age of patients was 66.2 ± 11.5 years. Seven (70 %) patients suffered from rheumatoid arthritis, and three (30 %) had idiopathic osteoarthritis.

Before surgery, the mean intra-articular valgus deformity was 24.8 ± 2.7º (minimum – 20º, maximum – 29º). The average knee joint function on the KSS scale was 15.5 ± 8.9, KSS function was 21.4 ± 12.5, and WOMAC score was 35.2 ± 8.2 points. Statistical analysis of the data was carried out with the determination of the standard deviation of the parameters studied.

In all the ases, valgus deformity of the knee joint was fixed associated with pronounced frontal instability and the extra-articular component (constitutional varus deformity of the femur, valgus deformity of the proximal tibia or a combination of both) and was referred to Krackow type III.

In all 12 arthroplasties, a sliding osteotomy of the lateral condyle of the femur was performed to eliminate the knee joint imbalance followed by bringing the slid fragment down and its fixation with screws. Thanks to this, an adequate balance was achieved intraoperatively and allowed implantation of a partially constrained prosthesis with replacement of the posterior cruciate ligament in all our patients.

Statistical processing of data was carried out using the STATISTICA software program. Most of the data studied did not correlate with the normal distribution, so we used nonparametric statistics for processing, in particular the Mann-Whitney-Wilcoxon test and the Kruskal-Wallis criterion.

PREOPERATIVE PLANNING AND KNEE ARTHROPLASTY TECHNIQUE WITH A SLIDING OSTEOTOMY OF THE LATERAL FEMORAL CONDYLE

Clinical examination of the knee joint

The locomotion function, the degree of lower limb deformity at the level of the knee joint in the frontal and sagittal planes, the amount of passive and active movements in the knee joint, the degree of frontal and sagittal instability, the presence of contracture of the knee joint (flexion, extension, combined) were examined. When assessing the condition of the knee joint, attention was paid to the possibility of passive correction of the anterior deformity in the knee joint (how much lateral ligamentous complex was rigid and to what extent is the medial one was hypermobile). If the valgus deformity was easily corrected, the intra-operative balance of the knee joint was easily achievable. Presence of a fixed valgus deformity was a sign of the need for intra-operative use of extended release elements or the use of prostheses stabilized in the frontal plane.

Radiographic study of patients

The patients under the study underwent radiography of the knee joint in 2 projections, the radiograph of the knee joint under stress, and the telemetric radiography of both lower extremities. Deforming arthrosis grade, the nature of destructive changes, the type of frontal deformity and its severity were assessed.

In the anteroposterior (AP) radiographs of the lower limbs, the planned distal femoral bone and the proximal tibia saw lines as well as an expected trapezoidity of the knee joint were assessed. The reference angles and lines of the lower limb bones and the degree of their deviation from normal values were evaluated. In the study group of patients, eight patients had constitutional varus deformity and valgus deformity of the distal femur. Four individuals had a combination of valgus deformity of the distal femur and of the proximal tibia. In all the patients studied, the extra-articular deformities of the femur and tibia were no more than 7°. Therefore, none of the patients had a situation that would require corrective osteotomy of the bones forming the knee joint before arthroplasty. In the course of preoperative planning, the correctness of the distal femur saw line was assessed. In all the cases, the saw line did not go beyond the attachment points of the collateral ligaments, which served as a marker for the possibility to implement arthroplasty without any intervention to correct the limb axis.

The intramedullary guider insertion point was planned for adequate positioning of the femoral resection block. Due to a high probability of using constrained designs during arthroplasty, preoperative planning was performed taking into account the possibility of performing this option (the possibility of using intramedullary extension stems, the need for using metal blocks, etc.).

Surgical technique

An anterolateral approach was used according to the technique proposed by Keblish [13]. Bypassing the patella from the lateral side and forming a non-free fat flap from the Hoff's body, arthrotomy of the knee joint followed (**Fig. 1**).

Thereby, the fat flap pedicle remained fixed to the anterolateral part of the joint capsule not to disturb the blood supply to the flap (due to the preservation of one of the branches of the popliteal artery - the lateral inferior artery) [14] (**Fig. 2**).

Fig. 1 Lateral approach by Keblish. Dotted line is arthrotomy line

Fig. 2 Formation of a non-free fat flap

Next, along the surgical approach, a subperiosteal detachment of the ilio-tibial tract from the Gerdy tubiculum and an intersection of the ilio-tibial tract at the level of the joint gap, and the section of the posterolateral part of the joint capsule between the tendon of the popliteal muscle and the lateral collateral ligament were performed. When performing a lateral soft-tissue release, the lateral collateral ligament and the tendon of the popliteal muscle were left intact.

Once the standard distal femur and the proximal tibia sawing (measured resection with an extramedullary technique), the parameters of the extensor gap were evaluated using a tensor (**Fig. 3**).

In all the cases, a trapezoidal shape of the extension space was observed in patients with valgus deformation of type III (large space was on the medial side of the joint). Imbalance by its tensiometric evaluation was from 9 to 12 mm in the studied group of patients (**Fig. 4**).

In accordance with our concept proposed, the imbalance revealed intra-operatively on the basis of tensiometric measurements confirmed the necessity of correcting the dimensions of the extension gap with the use of a sliding osteotomy of the lateral condyle of the femur (**Fig. 5**).

Next, to correct the extension gap, an osteotomy of the femoral epicondyle of the femur was performed with a bone fragment formed not less than 1.5 cm wide. The osteotomy line should pass outside the lateral cortical layer of the femoral diaphysis. The osteotomized epicondyle with fixed lateral ligamentous structures was displaced distally to the amount of the measured tensiometric imbalance. The bone fragment was fixed with two 6.5-mm screws and then the distal part of the bone fragment protruded was resected (**Fig. 6**).

The length of the screws was selected in such a way that their end part reached the cortex of the medial condyle of the femur. After the bone fragment was fixed, the rectangular shape of the extension gap and its isotonicity was checked using the tensor (**Fig. 7**).

Since it is impossible to determine the degree of external rotation of the femoral component by the anatomical marks after the sliding osteotomy of the femoral condyle due to the change in the trans-epicondylar line, the parameters of the flexion gap and its correction were determined by the character and the magnitude of the correct rotation of the femoral component with the help of a tensor. Then, the final stages of distal femur resection (anterior, posterior and oblique resections), preparation of the femur notch for the rear stabilizer, and a final preparation of the bone bed for the tibial component were performed.

Having checked the correctness of the achieved balance of the extension and flexion spaces, a trial fitting of the prosthesis was performed: the size of the tibial liner, the axis of the limb, the volume of movements in the knee joint, and the tracking of the patella were assessed. Having verified the satisfactory position of the implant components and achieving the required balance of the knee during the trial assembly, the implant components in the femoral and tibial bones were finally fixed using a single package of bone cement (40 g). The joint was washed with solutions of an antiseptic and the wound was sutured layer-by-layer (**Fig. 8**).

Fig. 3 Tensor for evaluating the symmetry of the knee joint flexion and extension spaces

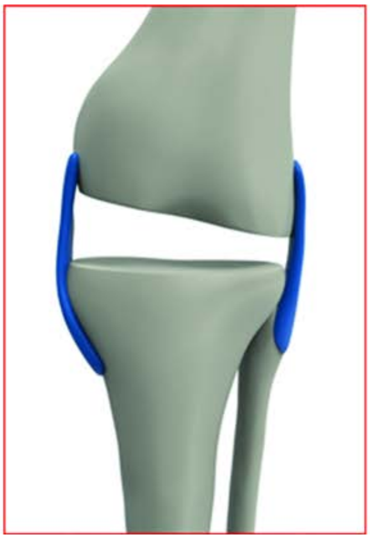

Fig. 4 Trapezoidal extension space; completed components of the initial soft tissue release did not allow for balancing the knee joint

Fig. 5 Layout of a planned osteotomy

Fig. 6 Bone fragment sliding and fixation with screws

Fig. 7 Rectangular extension gap of the knee joint formed

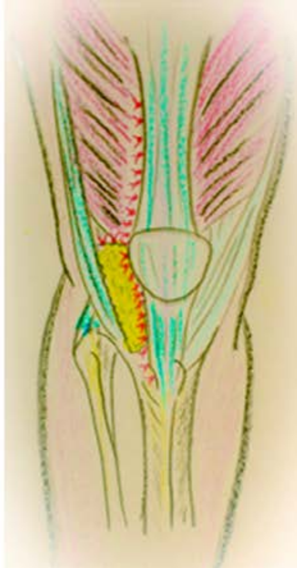

Fig. 8 Defect of the knee joint capsule is covered with a fat flap

Postoperative management of this group of patients did not differ from the rehabilitation program after the standard primary arthroplasty. External immobilization was not applied. Patients began to walk with crutches from the first day after the operation and developed the movements in the operated knee joint. All patients used compression elastic knitwear on both lower extremities in the early postoperative period, received anticoagulant therapy according to generally accepted patterns.

Clinical case Patient S., 73 years old, was admitted to department 7 of the Vreden RRITO of the Ministry of Health of Russia with the diagnosis: right-side idiopathic gonarthrosis in grade III, valgus deformity, flexion-extension contracture of the right knee joint (**Fig. 9**). The patient was examined on admission. It was revealed that the frontal deformity at the level of the knee joint was 30°, fixed III type according to Krackow (**Fig. 10**). Seven days later, the patient underwent total cemented artroplasty of the right knee and replacement of the posterior cruciate ligament (**Fig. 11** and **Fig. 15**). During the operation, a sliding osteotomy of the lateral condyle of the femur with a distalization of the fixation point of the lateral collateral ligament and the tendon of the popliteal muscle was performed to correct deformity and for balancing the knee joint. In the postoperative period, the patient was rehabilitated, trained to walk with crutches. The postoperative wound healed by primary tension. The patient continued walking with crutches for 4 weeks after the operation. She used a cane the next 4 weeks and later started to walk without additional supports (**Fig. 12**).

Radiographic examination revealed varus deformity at the level of the femoral diaphysis and valgus deformity of the distal femoral third (LDFA (lateral distal femoral angle) 75°) (**Fig. 13**). The reference angles and tibial lines did not go beyond the normal range, although the presence of a deep defect in the lateral condyle of the tibia and a pronounced lateral osteophyte did not allow an absolutely reliable assessment of the correctness of the MPTA (medial proximal tibial angle).

IM valgus correction angle (IM angle) is the intramedullary angle of the valgus femoral deflection which varies from 2° to 9-12° in the population, was 9° in the presented X-ray (**Fig. 14**) [15]. This circumstance could make it difficult to perform total arthroplasty without prior radiographic planning by teleradiography because many orthopaedists routinely use the angle of valgus deflection 6° in the intramedullary guider for the orientation the distal resection unit.

The neutral axis of the limb was restored.

One year after the operation, the patient was followed-up and clinically examined. She walks without additional support, does not limp. The axis of the right lower limb is correct visually, the range of motion in the knee joint: extension/flexion 0°/0°/110° (**Fig. 15**). The KSS score was 86, KSS function scored 82, and the WOMAC score was 90 points (www.orthopaedicscore.com).

Fig. 9 AP and lateral radiographs of the right knee joint prior to surgery

Fig. 10 Patient's photos before surgery

Fig. 11 AP and lateral radiographs of the right knee joint after surgery

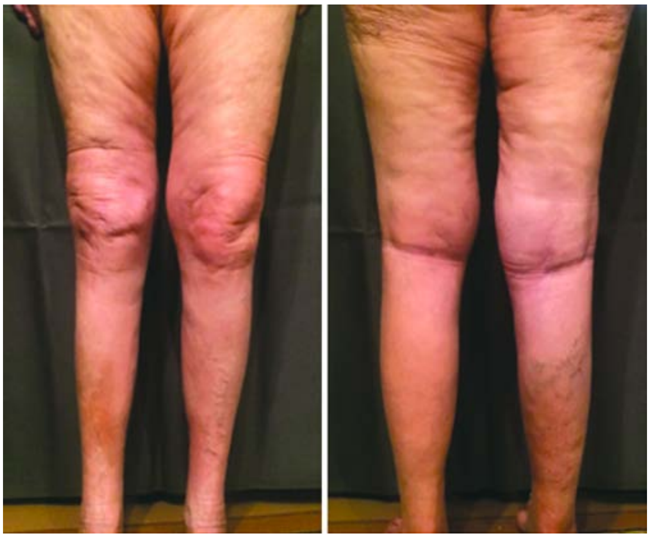

Fig. 12 Patient's photos after surgery

Fig. 13 Telemetric image of the lower limbs taken before surgery

Fig. 14 X-rays of the patient showing the planned level of resection in the femur and tibia

Fig. 15 Telemetric image of the lower limbs after surgery

RESULTS

All 10 patients who took part in the study underwent implantation of posterior stabilized prostheses of one and the same manufacturer, cemented fixation, with a fixed polyethylene insert. Implantation of stabilized in the frontal plane or fully constrained oprosthesis was not needed. The treatment results were evaluated 12 months after the intervention. The average of knee joint function KSS score was 82.3 ± 6.4, KSS function was 74.5 ± 16.4, and the WOMAC score was 85.4 ± 10.1 points (**Fig. 16**). Eight surgical interventions (64 %) showed excellent functional results, good were 4 (36 %). There were no fair or poor outcomes.

In our series of observations after these operations, complication happened in one case (8.3 %). On the 5th day after the operation, a periprosthetic metadiaphyseal fracture of the femur (type 2 according to the Lewis and Rorabeck classification) occurred in one of the patients and femur osteosynthesis was performed with a locking intramedullary nail [2]. Fracture of the femur was associated with the patient's fall on the operated limb. The fracture of the femur was not associated with the migration of the osteotomized epicondyle of the femur.

We did not observe migration of fixation screws in the group of examined patients within the estimated follow-up control. We also did not perform their removal in the postoperative period.

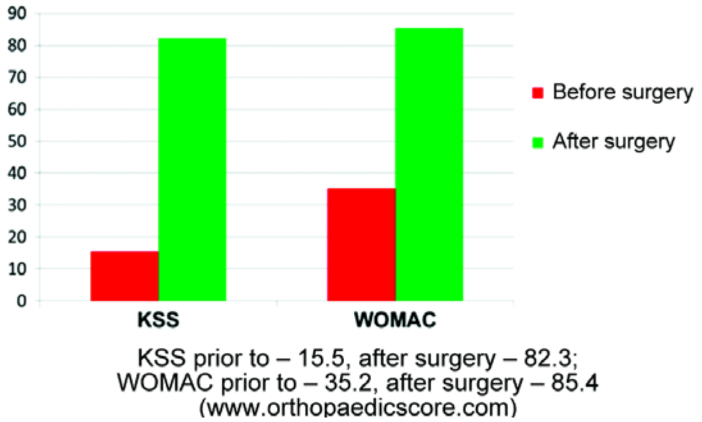

Fig. 16 Functional results of the operated limb in patients with a sliding osteotomy of the lateral femoral condyle evaluated before the operation and 12 months after arthroplasty

DISCUSSION

Soft tissue release is of the utmost importance by performing arthroplasty of the knee joint in the patients with fixed valgus deformity. At the moment, there are many options for its implementation that differ in the sequence and extent of soft tissues exposure. However, it is impossible to single out the only universal technique used that has shown its undoubted effectiveness and safety [6, 8, 16].

Krackow and Mihalko conducted an anatomical study on the evaluation of changes in the flexion and extension spaces after the release of stabilizing soft tissue formations in the lateral compartment. The authors found that the early release of the lateral collateral ligament provides a more uniform change in the flexion and extension gaps. In their opinion, with severe valgus deformity, the release of the lateral collateral ligament should be performed first of all, and of the tendon of the popliteal muscle and the ilo-tibial tract should go after it [17]. In view of this fact, the benefits of the release of the lateral collateral ligament are the elimination of a fixed valgus deformity by lengthening the lateral collateral ligament to an exactly required amount. It allows the precise control of the change in the flexion and extension space. The most effective way is a sliding osteotomy of the lateral condyle of the femur with transposition and distalization of the fixation site of the lateral collateral ligament and the tendon of the popliteal muscle.

This manipulation provides a good functional result in arthroplasty performed in patients with severe valgus deformity of the knee joint. Hadjicostas and Soucacos evaluated the results of 15 knee joint arthroplasties with computer navigation and a sliding osteotomy of the lateral condyle. The researchers used posteriorly stabilized cemented fixation implants with a fixed platform in all their cases and achieved the following results: mean KSS scores increased from 37 to 90 points after surgery. Sliding osteotomy of the lateral femoral condyle resulted in the neutral limb axis in all the patients and the stability of the joint was preserved by flexion and extension. There were no recorded cases of patellar dislocation or peroneal nerve injury [18].

Mullaji and co-authors also used computer navigation while performing sliding osteotomy of the lateral condyle of the femur. This technology allowed them to exclude the implementation of an extensive soft tissues release in the lateral joint compartment and at the same time achieve similar results [19]. In our study, a tensiometric technique was used to assess the symmetry of the flexion and extension spaces. It enabled to achieve a good balance of the knee joint with the precision not inferior to computer navigation.

In the opinion of several authors, the results of arthroplasty with the implementation of sliding osteotomy of the lateral condyle of the femur do not fundamentally differ from the results of primary knee joint arthroplasty without it [11]. This coincides with the data obtained by us. In the group of patients studied, the KSS score increased from 15.5 to 82.3 and the KSS function score from 21.4 to 74.5 points after arthroplasty combined with the sliding osteotomy of the lateral condyle of the femur.

According to some authors, the sliding osteotomy of the lateral condyle of the femur can be associated with a number of complications, and namely, with a possible nonunion in the zone of osteotomy. To prevent this, great attention should be paid to achieving the absolute stability with qualitative internal fixation. Thus, Brillhaut recommends the use of a bone plate to fix the bone fragment to prevent such a complication [20].

In the patients operated by us, there were no cases of the lateral condyle nonunion, but there was one case of periprosthetic fracture of the femur.

In conclusion, I would like to note that the sliding osteotomy technique is easy to reproduce, allows avoiding the implantation of a constrained implant and reduces the expenditures for patient treatment. Moreover, it is a highly effective means of correcting valgus deformity. However, there are not so many works at the moment that highlight the effectiveness and safety of this procedure, as well as there is no generally accepted technique for its implementation.

It is possible that the reason for the rare application of the procedure described is a relatively low occurrence of this knee joint pathology. Thus, according to Vreden RRITO register, 1437 knee joint arthroplasties were performed in patients with valgus deformity during the recent 5-year period. Implantation of constrained implants of CCK/VVC type was performed in 114 cases (7.933 %). Sliding osteotomy of the lateral condyle with transposition of the fixation point of the lateral collateral ligament during the procedure of knee joint arthroplasty was required in only 12 cases. Therefore, there is absence of conventional indications and a limited use of sliding osteotomy as a highly effective method for achieving balance in total knee arthroplasty in patients with fixed valgus deformity. There is no convincing evidence of this manipulation safety.

CONCLUSIONS

Sliding osteotomy of the lateral femoral condyle performed to distalize the attachment point of the lateral collateral ligament and the popliteal tendon during knee joint arthroplasty due to osteoarthritis with a pronounced fixed valgus deformity of type III according to the Krakow classification allows balancing the joint and achieving good and excellent functional results using a standard knee arthroplasty protocol. However, the safety of this procedure requires further study.

REFERENCES

1. Ignatenko V.L., Kornilov N.N., Kulyaba T.A., Selin A.V., Petukhov A.I., Kroitoru I.I., Saraev A.V. Endoprotezirovanie pri val'gusnoi deformatsii kolennogo sustava (obzor literatury) [Arthroplasty for the knee valgus deformity]. *Travmatologiia i Ortopediia Rossii*, 2011, no. 4 (62), pp. 140-146. (In Russian)
2. Kornilov N.N., Kulyaba T.A. *Artroplastika kolennogo sustava* [Arthroplasty of the knee]. SPb.: RNIITO, 2012, 228 p. (In Russian)
3. Kornilov N.N.,. Kulyaba T.A, Novoselov K.A. *Endoprotezirovanie kolennogo sustava* [Arthroplasty of the knee]. SPb.: Gippokrat, 2006, 176 p. (In Russian)

4. Pil'ni Ia., Kubesh I., Petrina M., Bacha V. Dolgosrochnye rezul'taty klinicheskogo primeneniia total'nogo endoproteza kolennogo sustava «Universal» [Long-term results of clinical using *Universal* total implant of the knee]. *Travmatologiia i Ortopediia Rossii*, 2015, no. 2 (76), pp. 32-28. (In Russian)
5. Brilhault J., Lautman S., Favard L., Burdin P. Lateral femoral sliding osteotomy lateral release in total knee arthroplasty for a fixed valgus deformity. *J. Bone Joint Surg. Br*., 2002, vol. 84, no. 8, pp. 1131-1137.
6. Thienpont E. *Improving Accuracy in Knee Arthroplasty*. 1st Edition. Jaypee Brothers Medical Publishers Ltd., 2012, 375 p.
7. Engh G.A. The difficult knee: severe varus and valgus. *Clin. Orthop. Relat. Res*., 2003, no. 416, pp. 58-63.
8. Girard J., Amzallag M., Pasquier G., Mulliez A., Brosset T., Gougeon F., Duhamel A., Migaud H. Total knee arthroplasty in valgus knees: predictive preoperative parameters influencing a constrained design selection. *Orthop. Traumatol. Surg. Res*., 2009, vol. 95, no. 4, pp. 260-266. doi: 10.1016/j.otsr.2009.04.005.
9. Hadjicostas P.T., Soucacos P.N., Thielemann F.W. Computer-assisted osteotomy of the lateral femoral condyle with non-constrained total knee replacement in severe valgus knees. *J. Bone Joint Surg. Br*., 2008, vol. 90, no. 11, pp. 1441-1445. doi: 10.1302/0301-620X.90B11.20092.
10. Keblish P.A. The lateral approach to the valgus knee. Surgical technique and analysis of 53 cases with over two-year follow-up evaluation. *Clin. Orthop. Relat. Res*., 1991, no. 271, pp. 52-62.
11. Kornilov N., Kulyaba T., Petukhov A., Ignatenko V., Thienpont E. Computer navigation helps achieving appropriate gap balancing and restoration of alignment in total knee arthroplasty for fixed valgus knee osteoarthritis irrespective of the surgical approach. *Acta Orthop. Belg*., 2015, vol. 81, no. 4, pp. 673-681.
12. Krackow K.A., Mihalko W.M. Flexion-extension joint gap changes after lateral structure release for valgus deformity correction in total knee arthroplasty: a cadaveric study. *J. Arthroplasty*, 1999, vol. 14, no. 8, pp. 994-1004.
13. Krackow K.A., Jones M.M., Teeny S.M., Hungerford D.S. Primary total knee arthroplasty in patients with fixed valgus deformity. *Clin. Orthop. Relat. Res*., 1991, no. 273, pp. 9-18.
14. Mullaji A.B., Shetty G.M. Lateral epicondylar osteotomy using computer navigation in total knee arthroplasty for rigid valgus deformities. *J. Arthroplasty*, 2010, vol. 25, no. 1, pp. 166-169. doi: 10.1016/j.arth.2009.06.013.
15. Nikolopoulos D., Michos I., Safos G., Safos P. Current surgical strategies for total arthroplasty in valgus knee. *World J. Orthop*., 2015, vol. 6, no. 6, pp. 469-482. doi: 10.5312/wjo.v6.i6.469.
16. Peters C.L., Mohr R.A., Bachus K.N. Primary total knee arthroplasty in the valgus knee: creating a balanced soft tissue envelope. *J. Arthroplasty*, 2001, vol. 16, no. 6, pp. 721-729.
17. Rawal J., Devany A.J., Jeffery J.A. Arthroplasty in the Valgus Knee: Comparison and Discussion of Lateral vs Medial Parapatellar Approaches and Implant Selection. *Open Orthop J*., 2015, vol. 9, pp. 94-97. doi: 10.2174/1874325001509010094.
18. Rorabeck C.H., Taylor J.W. Classification of periprosthetic fractures complicating total knee arthroplasty. *Orthop. Clin. North Am*., 1999, vol. 30, no. 2, pp. 209-214.
19. Rossi R., Rosso F., Cottino U., Dettoni F., Bonasia D.E., Bruzzone M. Total knee arthroplasty in the valgus knee. *Int. Orthop*., 2014, vol. 38, no. 2, pp. 273-283. doi: 10.1007/s00264-013-2227-4.
20. Whiteside L.A. Correction of ligament and bone defects in total arthroplasty of the severely valgus knee. *Clin. Orthop. Relat. Res*., 1993, no. 288, pp. 234-245.
21. Whiteside L.A., Arima J. The anteroposterior axis for femoral rotational alignment in valgus total knee arthroplasty. *Clin. Orthop. Relat. Res*., 1995, no. 321, pp. 168-172.
22. Wolff A.M., Hungerford D.S., Pepe C.L. The effect of extraarticular varus and valgus deformity on total knee arthroplasty. *Clin. Orthop. Relat. Res*., 1991, no. 271, pp. 35-51.

Received: 03.02.2017

Information about the authors:

1. Dmitrii V. Stafeev, M.D., Ph.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia, Department of Traumatology and Orthopaedics No 7; SBEI HPE *Northwest St. Petersburg Mechnikov Medical University* of the RF Ministry of Health, St. Petersburg, Department of Traumatology and Orthopaedics
2. Dmitrii V. Chugaev, M.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia, Diagnostic Department of Diseases and Injuries of the Locomotor System, Department of Traumatology and Orthopaedics No 7; e-mail: dvchugaev@rniito.ru
3. Nikolai N. Kornilov, M.D., Ph.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia, Department of the Knee Pathology; SBEI HPE *Northwest St. Petersburg Mechnikov Medical University* of the RF Ministry of Health, St. Petersburg, Department of Traumatology and Orthopaedics
4. Sergei A. Lasunskii, M.D., Ph.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia, Head of Department of Traumatology and Orthopaedics No 7
5. Evgenii P. Sorokin, M.D., Ph.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia, Diagnostic Department of Diseases and Injuries of the Locomotor System
6. Andrei D. Sineokii, M.D., Vreden Russian Research Institute of Traumatology and Orthopedics, St. Petersburg, Russia