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**Original article**

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# *Personalized approach to the treatment of patients with medial meniscus tear combined with varus deformity of the tibia*

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***Abstract***

**Introduction** Meniscus tear is one of the most common injuries of the knee joint. Medial meniscus tear accounts for 23–31 % of knee joint injuries. The main method of treatment is partial resection. As reported, 13.5 % of patients undergo arthroplasty within 15 years after meniscus resection, what is regarded as an unsatisfactory result. **Purpose** To evaluate and compare the long-term clinical, functional and radiological results of surgical treatment in patients with medial meniscus tear combined with varus deformity of the tibia and without it. **Materials and methods** From 2013 to 2020, medial meniscus tear was treated in 245 patients. The patients were divided into 4 groups. Group 1 included patients with a mechanical femorotibial angle (MFTA) from 0º to 3º who had arthroscopic meniscus resection (AMR). In the 2nd group, all patients also underwent AMR, but their MFTA was more than 3º. In group 3, patients with MFTA from 3º to 5º underwent simultaneous AMR and proximal fibular osteotomy (PFO) with the formation of a defect. Group 4 included patients with MFTA more than 5º, who underwent high tibial osteotomy (HTO) and AMR. Changes in the main lines and angles were assessed with telemetry radiography of the lower extremities. Functional results were evaluated before and after surgery using the Lysholm Knee Scoring Scale, 2000 IKDC, KOOS. **Results** Isolated meniscus resection in patients with MFTA more than 3º without axial correction leads to a gradual increase in the deformity by 1,070 ± 0.50º during the first year after surgery, and by 2.20 ± 0.70º to the fifth year. In groups 1, 3 and 4, there was no statistically significant increase in MFTA during the entire observation period. The clinical treatment results of patients of the four groups in the first three years after surgery did not differ statistically. However, within the period from 3 to 5 years, patients with MFTA greater than 3º who underwent only AMR had poorer clinical results than in the other groups ($p < 0.001$). **Conclusions** A personalized approach to the method of surgical treatment for medial meniscus tear based on the MFTA enables to correct the mechanical axis of the lower extremities and MFTA, and thus improve the long-term clinical, functional and radiological results of surgical treatment.

***Keywords***: meniscus tear, varus tibial deformity, high tibial osteotomy, proximal fibular osteotomy

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## INTRODUCTION

Meniscus tears are one of the most common injuries of the knee joint. According to domestic and foreign authors, their incidence ranges from 0.61 to 0.70 per 1.000 people a year, but reaches 8.27 among young patients with a high level of physical activity [1-3]. As far as law enforcement officers are subjected to increased physical exertion due to the specifics and nature of their service, the rate of meniscus injuries is 15–20 % higher than among the civilian population. There is also a high frequency of meniscus injuries among athletes of various team sports, especially football players, basketball players and wrestlers [4].

One of the main methods of meniscus tear management is its partial or subtotal resection. However, the evaluation of patients 15 years after meniscectomy brought disappointing results. Thus, 13.5 % of patients underwent arthroplasty within 15 years after the operation, and in females it was performed twice as frequent as in males [5]. Moreover, arthroplasty after meniscus resection was performed 10 times more often than the average in the population. The situation is more disastrous in the group of young patients under the age of 40, where the frequency of arthroplasty increases 40 times [5]. This is primarily due to the fact that the function of the meniscus has been underestimated for a long time. If resected, the biomechanical relationships in the knee joint changes and results in irreversible damage to the cartilage covering the articular surfaces of the bones. One of the main risk factors leading to the progression of deforming arthrosis of the knee joint is a disorder of the mechanical axis of the lower limb, and namely, varus deformity of the lower leg [6]. In their study, Yoon K.H. et al. showed that resection of the medial meniscus leads to progression of varus deformity by 1.7 ± 1.5° [7]. Changwan Kim et al. assessed the progression of the deforming arthrosis according to Kellgren–Lawrence and the change in joint space height in patients who underwent resection of the medial meniscus. The patients were divided into two groups, the first included patients with a normal preoperative axis of the lower extremities, and the second included patients with a varus deformity of more than 3°. The

study concluded that in the patients of the first group, the differences in the stage of deforming arthrosis and the height of the joint space before and after surgery were not statistically significant, and in the second group there was a significant progression of deforming arthrosis and a decrease in the height of the joint space [8]. Thus, the angle of varus deformity affects the results of treatment of patients with a torn medial meniscus.

To correct varus deformity of the tibia, HTO has been currently used in clinical practice [9, 10]. However, HTO remains controversial in mild deformity. In such cases, PFO can be used to unload the medial compartment of the knee joint [11, 12]. These operations can be considered as prophylactic interventions aimed at preventing the development of gonarthrosis [13–15].

Currently, there is no algorithm and indications for surgical treatment in patients with medial meniscus injury combined with varus deformity of the leg.

The **aim** of the study was to evaluate the mid-term clinical, functional and radiological results of surgical treatment of patients with medial meniscus injury in combination with varus deformity of the lower leg, and based on a comparative analysis of the data, to determine the indications for performing an isolated arthroscopic meniscus resection and its simultaneous use with various osteotomy techniques.

## MATERIAL AND METHODS

The study included 245 patients who were treated at the Center for Traumatology and Orthopedics of the Federal State Budgetary Institution "N.N. Burdenko Chief Military Clinical Hospital" of the Russian Ministry of Defense for injuries of the medial meniscus in the period from 2013 to 2020. The age of the patients ranged from 21 to 41 years (mean age 31.5 ± 5.7 years). The study was conducted in accordance with the ethical and legal norms and standards stated in the Declaration of Helsinki. Informed consents of the persons included in the study were obtained.

In the preoperative period, patients were examined and knee joint function was assessed using the *Lysholm Knee Scoring Scale, 2000 IKDC, KOOS*. A standard clinical examination of the knee joint and radiodiagnosis (radiography of the knee joint in frontal and lateral viewss, teleroentgenometry of the lower extremities, magnetic resonance imaging (MRI)) were carried out. Thereby, the mechanical axis of the lower extremities that passes from the center of the femoral head to the center of the trochlea of the talus; the point of its passage through the knee joint (as a percentage from the width of the tibial plateau); mechanical femorotibial angle (MFTA) being the angle between the mechanical axis of the femur and tibia; medial proximal tibial angle (mMPTA) being the angle of the tibial plateau inclination; dynamics of development of osteoarthritis (stage according to Kellgren-Lawrence) were evaluated.

Inclusion criteria were isolated damage to the medial meniscus of the knee joint, available MRI data and radiographs at all stages of observation. Depending on the angle of varus deformity and the chosen tactics of surgical treatment, the patients were divided into four groups. Group 1 included patients with MFTA from 0° to 3° who underwent AMR. In group 2, all patients also underwent AMR, and MFTA before surgery was more than 3°. In group 3, patients with varus deformity from 3° to 5° underwent simultaneous AMR and proximal osteotomy of the fibula (PFO) with the formation of its defect. Group 4 (60 patients, 24.5 %) included patients with MFTA more than 5°, who underwent high tibial osteotomy (HTO) of the "opening wedge" type and resection of the medial meniscus.

The exclusion criteria were various types of instability of the knee joint, degenerative or post-traumatic changes in the lateral parts of the knee joint, accompanied by damage to the lateral meniscus, osteochondropathy, hallux valgus, as well as patellofemoral arthrosis, various autoimmune diseases.

All patients underwent standard arthroscopy of the knee joint with assessment of the internal structures and partial or subtotal resection of the medial meniscus, depending on the degree of its damage.

In group 3 patients, arthroscopic meniscectomy was supplemented with PFO with an ectomy of the fibular fragment to form a defect. The osteotomy of the fibula was performed 5 cm distal to the neck of the fibula to exclude damage to the common peroneal nerve. An incision was made in the skin and subcutaneous fat over the fibula, 4–5 cm long. After that, the superficial fascia of the lower leg was opened, the muscles were bluntly parted, and the diaphysis of the fibula was exposed. Using an oscillating saw, an osteotomy of the fibula was performed with the formation of a defect from 0.5 to 1.0 cm, the bone fragment was removed. The stages of the operation are shown in Figure 1.

Patients of group 4 were simultaneously subjected to opening wedge HTO and bone grafting of the formed tibial defect with an autograft from the iliac crest. The osteotomy was performed using the Hinge Pin System, which reduces the risk of fracture of the lateral cortical plate of the tibia. The tibia was fixed with a special plate with 4 holes for screws (2 distally and 2 proximally) and a block between them, corresponding to the size of the wedge and holding its height. The block on the plate was chosen depending on the required angle of correction in accordance with preoperative planning. The stages of the operation are shown in Figure 2.

Comparison and evaluation of treatment results in groups was carried out 1, 3 and 5 years after surgery. The obtained data were statistically processed using the Microsoft Excel application and the statistical data analysis package IBM SPSS Statistics. The Kolmogorov-Smirnov test was used to check the normality of the distribution. In a normal distribution, quantitative data are presented as mean ± standard deviation; in a non-normal distribution, quantitative data are presented as a median and interquartile range ($25^{th}$ and $75^{th}$ percentiles). Comparison of two groups with a normal distribution of quantitative data was carried out using Student's t-test; for three or more groups using one-way analysis of variance. When comparing two or more groups whose data do not correspond to a normal distribution, the Kruskal-Wallis test was used. Difference was considered statistically significant at $p < 0.05$.

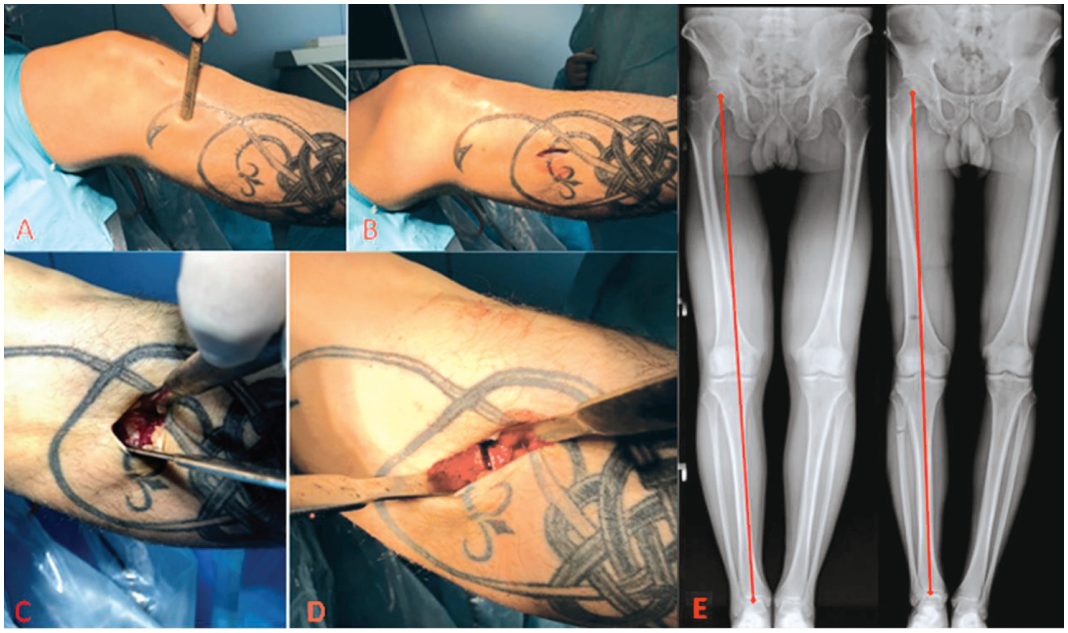


**Fig. 1** Stages of the operation in proximal osteotomy of the fibula: A – palpation of the head and neck of the fibula; B – surgical approach 5 cm distal to the neck of the fibula; C – exposure of the fibula; D – osteotomy of the fibula with the formation of its defect; E – preoperative and postoperative telemetry of the lower extremities

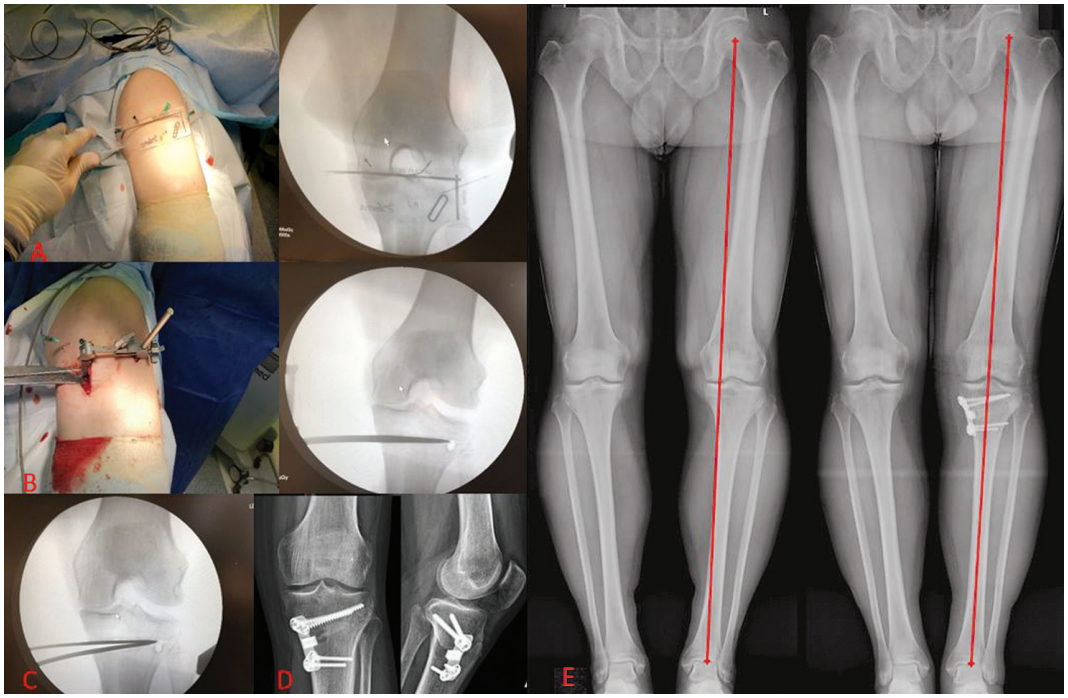


**Fig. 2** Stages of the operation with performance of a high valgusation osteotomy of the tibia according to the "opening wedge" type. A – application of a special X-ray guide to choose the Hinge Pin installation point; B – installation of a block on the Hinge Pin and the choice of the angle of sawing the tibia; C – opening the wedge of the tibia to the required angle of correction; D – fixation of tibial fragments with a 4-hole locking plate; E – preoperative and postoperative telemetry of the lower extremities

## RESULTS

Radiological results of treatment (Table 1) in patients of group 1 showed no significant change in the mMPTA angle at all follow-up periods (p1 = 0.8; p2 = 0.8; p3 = 0.5) (Table 2). A significant ($p < 0.001$) increase in the deformityn angle by 0.26 ± 0.07° and a change in the position of the mechanical axis (0.33 ± 0.09 %) are noted. However, given the slight change in indicators, as well as a small sample of patients, these values were regarded as statistically insignificant. In group 2, an increase in the angle of varus deformity was revealed, compared with the preoperative value, and its gradual increase over time: during the first year after surgery by 1.07 ± 0.5°, and by 2.2 ± 0.7° in the fifth year ($p < 0.001$). Moreover, there was a medial displacement of the mechanical axis by 9.76 ± 1.2 % to the 5th year of follow-up observation. There was no significant change in the mMPTA angle in group 2 (p1 = 0.058; p2 = 0.058; p3 = 0.058). In group 3, a decrease in the angle of varus deformity was registered one year after surgery by an average of 2.84 ± 0.7° ($p < 0.001$); subsequent observation did not reveal any significant change. In group 4, a significant decrease in the angle of varus deformity by 7.07 ± 2.3° and a lateral shift of the mechanical axis of the lower limb ($p < 0.001$) were determined. Thus, the MFTA was corrected to 0.8 ± 1.23°, and the mechanical axis passed through 49.32 ± 1.43 % of the area of the tibial plateau, what actually corresponds to the center of the knee joint. A change in the mMPTA angle was noted only in group 4, which was associated with the osteotomy of the tibia, on average, the angle increased by 7.19 ± 1.4° ($p < 0.001$) a year after the operation (Tables 1 and 2, Fig. 3).

Table1

Radiographic findings of treatment

| | Group | Before surgery | After surgery | | |
|---|---|---|---|---|---|
| | | | 1 year | 3 years | 5 years |
| MFTA, degrees | 1 | 1.50 ± 1.13 | 1.68 ± 1.15 | 1.70 ± 1.15 | 1.76 ± 1.14 |
| | 2 | 6.63 ± 1.91 | 7.70 ± 1.94 | 8.73 ± 2.07 | 9.83 ± 1.97 |
| | 3 | 4.05 ± 0.89 | 1.21 ± 0.89 | 1.36 ± 0.87 | 1.43 ± 0.77 |
| | 4 | 7.87 ± 1.85 | 0.80 ± 1.23 | 0.71 ± 1.16 | 0.79 ± 1.12 |
| Mechanical axis, % | 1 | 47.55 ± 1.93 | 47.37 ± 1.88 | 47.31 ± 1.89 | 47.22 ± 1.89 |
| | 2 | 33.57 ± 7.85 | 31.11 ± 7.63 | 27.68 ± 8.65 | 23.81 ± 8.81 |
| | 3 | 43.69 ± 2.46 | 48.85 ± 0.93 | 48.72 ± 0.94 | 48.67 ± 0.88 |
| | 4 | 29.28 ± 8.17 | 49.32 ± 1.43 | 49.44 ± 1.27 | 49.36 ± 1.28 |
| mMPTA, degrees | 1 | 86.72 ± 1.38 | 86.70 ± 1.38 | 86.67 ± 1.39 | 86.66 ± 1.42 |
| | 2 | 81.76 ± 1.43 | 81.69 ± 1.40 | 81.63 ± 1.44 | 81.55 ± 1.48 |
| | 3 | 84.21 ± 1.00 | 84.64 ± 1.04 | 84.75 ± 1.13 | 84.90 ± 1.06 |
| | 4 | 80.98 ± 1.40 | 87.30 ± 0.83 | 87.23 ± 0.85 | 87.17 ± 0.85 |

Table 2

Confidence level of differences of radiographic treatment results

| | Intragroup confidence level, p | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | MFTA | | | Mechanical axis | | | mMPTA | | |
| | p1 | p2 | p3 | p1 | p2 | p3 | p1 | p2 | p3 |
| Group 1 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.8 | 0.8 | 0.5 |
| Group 2 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.058 | 0.058 | 0.058 |
| Group 3 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| Group 4 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

*Notes*: *p1* confidence level of differences between preoperative values and 1 year after surgery; *p2* confidence level of differences between preoperative values and 3 years after surgery; *p3* confidence level of differences between preoperative values and 5 years after surgery

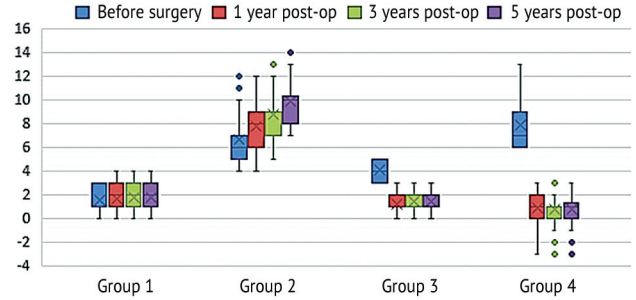


**Fig. 3** Change in the mechanical femorotibial angle

The functional results of treatment all groups at every follow-up period were significantly higher than before surgery ($p < 0.001$) (Table 4). However, in group 2, the comparison of the results after one year with the results after three and five years showed a pronounced decrease in clinical and functional parameters with all scales used for its evaluation (Table 3). In other groups, there was no significant decrease in the functional results of treatment (Tables 3 and 4, Fig. 4).

Six patients of group 2 (8.5 %) underwent total knee joint replacement within 5 years after the operation; in other groups, knee joint replacement was not performed within the entire period of follow-up.

Table 3

Functional results of treatment

| | Group | Before surgery | After surgery | | |
|---|---|---|---|---|---|
| | | | 1 year | 3 years | 5 years |
| Lysholm Knee Scoring Scale, points | 1 | 53.64 ± 3.80 | 91.93 ± 3.59 | 91.64 ± 3.53 | 90.91 ± 2.99 |
| | 2 | 53.83 ± 3.63 | 91.27 ± 3.60 | 80.10 ± 4.39 | 71.19 ± 2.86 |
| | 3 | 53.28 ± 3.85 | 93.46 ± 2.72 | 93.14 ± 2.28 | 93 (91.25; 94) |
| | 4 | 53.22 ± 3.65 | 92.75 ± 2.79 | 92.27 ± 2.75 | 91.98 ± 2.87 |
| 2000 IKDC, % | 1 | 21.24 ± 2.31 | 71.03 ± 2.56 | 70.90 ± 2.59 | 71 (70;73) |
| | 2 | 21.70 ± 2.48 | 70.57 ± 2.88 | 51.02 ± 2.32 | 51.33 ± 2.40 |
| | 3 | 22.21 ± 2.53 | 72.03 ± 1.66 | 72.17 ± 1.54 | 71.77 ± 1.36 |
| | 4 | 21.60 ± 2.53 | 71.68 ± 1.67 | 71.63 ± 1.75 | 71.71 ± 1.76 |
| KOOS, points | 1 | 144.74 ± 6.44 | 38.71 ± 3.92 | 40.56 ± 3.30 | 41.93 ± 3.44 |
| | 2 | 145.13 ± 7.27 | 39.60 ± 4.22 | 81.93 ± 4.81 | 111 (108; 113) |
| | 3 | 144.92 ± 7.23 | 37.49 ± 3.60 | 37.44 ± 3.43 | 38 (36; 39) |
| | 4 | 146.72 ± 7.74 | 38.60 ± 3.89 | 38.96 ± 3.91 | 38.74 ± 4.15 |

Table 4

Confidence level of differences in functionbal results

| | Intragroup confidence, p | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lysholm Knee Scoring Scale | | | 2000 IKDC | | | KOOS | | |
| | p1 | p2 | p3 | p1 | p2 | p3 | p1 | p2 | p3 |
| Group 1 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| Group 2 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| Group 3 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| Group 4 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

*Notes*: *p1* confidence level of differences between preoperative values and 1 year after surgery; *p2* confidence level of differences between preoperative values and 3 years after surgery; *p3* confidence level of differences between preoperative values and 5 years after surgery

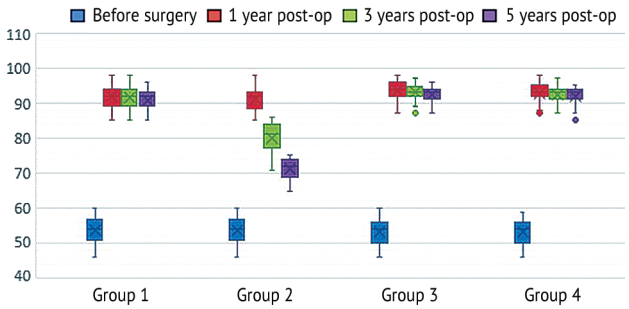


**Fig. 4** Changes in the survey results according to Lysholm Knee Scoring Scale

## DISCUSSION

Numerous studies appear in the domestic and world literature, in which the authors show the progression of deforming arthrosis of the knee joint after resection of the medial meniscus. However, good oucomes in the early postoperative period change into a large number of unsatisfactory outcomes in the long-term [16–18]. These studies regard various factors (body mass index, gender, stage of deforming arthrosis) that may influence the progression of osteoarthritis. However, it should be noted that not all patients, even in the presence of aggravating factors, have progression of deforming arthrosis. Even in the long-term period, a good functional result of treatment may be maintained in some patients [19, 20].

In our opinion, this is due to the fact that the studies underestimated the impact of varus deformity of the tibia on long-term clinical results of treatment in patients with medial meniscus injury.

The results of our study found that after resection of the medial meniscus in patients without varus deformity of the leg, there is no progression of MFTA and medial displacement of the mechanical axis of the lower limb in the postoperative period, and a good functional result is observed in this group of patients at all periods of follow-ups.

In varus deformity and preoperative MFTA greater than 3°, the MFTA significantly increases after resection of the medial meniscus, and medial displacement of the mechanical axis of the lower limb occurs. It is one of the main factors contributing to the progression of deforming arthrosis. This is primarily due to increased contact pressure between the femoral condyle and the tibial plateau [21, 22] resulting in pain and a decrease in the functional outcomes of treatment by the 3rd to 5th years after the operation, although one-year results were comparable with other groups.

Thus, surgical treatment of patients with medial meniscus tears and MFTA greater than 3° should not be limited to AMR only. It is necessary to perform operations aimed at correcting the axis of the lower limb. We evaluated the effectiveness of two methods of surgical treatment aimed at correcting the mechanical axis of the lower limb. The first is PFO, an easily reproducible operation that does not require specialized instruments and additional fixing devices. This operation is recommended in the initial stages of deforming arthrosis with varus deformity of the lower leg, as it allows to reduce contact pressure in the medial compartment of the knee joint [23, 24].

In patients with preoperative MFTA from 3° to 5°, PFO was performed in addition to AMR and corrected the mechanical axis by 2.2 ± 0.7°. PFO due to its simplicity and the absence of additional costs for implants, is very popular in the PRC and India. A number of authors describe good functional results after PFO in patients with severe varus deformity of the lower leg in the late stages of deforming arthrosis [25, 26]. This issue requires further study.

The second method for correcting varus deformity of the lower leg was HTO of the "opening wedge" type, which is indicated for patients with MFTA greater than 5° [27]. This operation is technically more demanding and requires additional surgical instruments, an image intensifier, and careful preoperative planning [9, 28]. In some cases, it is considered as an alternative to unicondylar arthroplasty for medial gonathrosis [14, 29]. This technique with proper implementation and competent correction of the angle can achieve good functional results both in the early and long-term [30].

## CONCLUSIONS

Arthroscopic meniscus resection is a currently used and a technically simple operation that allows patients to return fast to their previous lifestyle with good functional results. However, underestimation of the angle of varus deformity of the knee joint during this operation leads to the progression of deforming arthrosis and, as a result, to a large percentage of poor outcomes in the long-term period. Therefore, the performance of teleroentgenometry of the lower extremities with the assessment of MFTA at the preoperative stage is very important and should be routinely performed in all patients with damage to the medial meniscus.

In varus deformity with MFTA > 3°, resection of the medial meniscus should be supplemented with either proximal osteotomy of the fibula with the formation of its defect if MFTA ranges 3° to 5°, or high valgus osteotomy of the tibia of the “opening wedge” type in MFTA > 5° . Such an individual approach to the treatment of patients with damage to the medial meniscus in combination with varus deformity of the lower leg enables to correct the position of the mechanical axis of the lower limb and MFTA, thereby reducing the likelihood of the progression of deforming arthrosis of the knee joint.

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