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# Anatomical and functional prerequisites for the development of endoprosthesis instability after monocandylar knee arthroplasty

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*Monocondylar knee arthroplasty allows to restore normal kinematics and function of the knee joint in the case of osteoarthritis limited to the medial or lateral part of the joint. Objective. To identify the patterns and features of secondary anatomical and functional changes in the knee joint after monocandylar arthroplasty depending on the patient's gender, weight, etiology of gonarthrosis, the magnitude of the primary joint deformity and bone tissue condition. Methods. The results of the examination of 71 patients (age 37–83 years, follow-up period 3–10 years) were analyzed. In 20 (28.2 %) patients, problems with the arthroplasty joint occurred. joint: increased frontal deformity angle — 8 (40 %), decreased joint mobility — 12 (60 %), pain in the implantation area — 10 (50 %). Results. Preoperative factors that may affect the outcome of monocandylar knee arthroplasty were identified. The main one is reduced bone density, especially localized osteoporosis. In the presence of osteoporotic areas in the area of arthroplasty, the risk of endoprosthesis instability can reach 100 %. The second important factor is frontal deformities of the knee joint of more than 10°. Other factors, such as obesity, meniscal and crossed ligament injuries, fractures of the femoral and tibial condyles, also affect the development of complications, especially with a simultaneous decrease in bone mineral density and/or significant frontal deformity of the knee joint. Conclusions. Monocondylar knee arthroplasty is a reliable, cost-effective, low-traumatic method of treating gonarthrosis, but subject to clear indications for its implementation. In the long term, patients with osteoporosis, meniscal and ligamentous injuries, fractures of the condyles, and frontal deformities of more than 10° may develop signs of endoprosthesis instability.*

*Монокондилярне ендопротезування колінного суглоба дає змогу відновити нормальну кінематику та функцію колінного суглоба за умов остеоартрозу, обмеженому медіальним або латеральним відділом суглоба. Мета. Виявити закономірності й особливості розвитку вторинних анатомічних і функціональних змін у колінному суглобі після монокандилярного ендопротезування залежно від статі, ваги пацієнта, етіології гонартрозу, величини первинної деформації суглоба й стану кісткової тканини. Методи. Проаналізовано результати обстеження 71 пацієнта (вік 37–83 років, термін спостереження 3–10 років). У 20 (28,2 %) хворих виникли проблеми з ендопротезованим суглобом: збільшення кута фронтальної деформації — 8 (40 %), зменшення рухомості суглоба — 12 (60 %), біль у зоні імплантації — 10 (50 %). Результати. Виявлені передопераційні чинники, які можуть впливати на результат монокандилярного ендопротезування колінного суглоба. Головним серед них є знижена щільність кісткової тканини, особливо локальний остеопороз. За наявності остеопоротичних зон у ділянці ендопротезування ризик виникнення нестабільності імплантата може сягати 100 %. Другий важливий чинник — фронтальні деформації колінного суглоба понад 10°. Інші фактори, такі як ожиріння, травми менісків і схрещених зв'язок, переломи виростків стегнової та великогомілкової кісток також впливають на розвиток ускладнень, особливо за одночасного зниження мінеральної щільності кісток та/або значної фронтальної деформації колінного суглоба. Висновки. Монокондилярне ендопротезування колінного суглоба є надійним, ощадним, малотравматичним методом лікування гонартрозу, але за умов дотримання чітких показань до його виконання. У віддаленому періоді у пацієнтів з остеопорозом, травмами менісків і зв'язок суглоба, переломами виростків та фронтальними деформаціями понад 10° можуть сформуватися ознаки нестабільності ендопротеза. Ключові слова. Ендопротезування, колінний суглоб, гонартроз, ускладнення, нестабільність.*

**Key words.** Endoprosthetics, knee joint, gonarthrosis, complications, instability

## Introduction

Osteoarthritis of the knee joint (gonarthrosis) is one of the most common degenerative diseases of the musculoskeletal system, which significantly reduces the quality of life of patients, their motor activity and is a frequent cause of disability among people of working age [1]. The optimal technique for treating conditions when degenerative changes are localized in one of the parts of the joint is monocondylar endoprosthesis. The technique is a bone- and ligament-sparing procedure that reliably restores normal kinematics and function under the conditions of osteoarthritis of the knee joint, limited to its medial or lateral part [2]. Monocondylar endoprosthesis of the knee joint gives excellent functional results and implant survival under the conditions of proper selection of patients to whom it is appropriate to use this technique [3]. The ten-year survival rate of the endoprosthesis in cohort studies is more than 90 %, but the most common causes of complications in the postoperative period are its aseptic loosening and progression of osteoarthritis [4–6].

Indications for medial monocondylar knee arthroplasty have expanded over the past two decades [7]. Advantages include faster recovery, better kinematics, and functional outcomes compared to total arthroplasty, meaning the technique has the potential to be a cost-effective alternative to total knee replacement in certain patient populations. Therefore, the expansion of indications for use, careful examination of the patient and planning of operations can increase the number of specified surgical interventions, which will make it possible to improve the quality of life of patients and make it functionally complete.

*Purpose:* to identify patterns and features of the development of secondary anatomical and functional changes in the knee joint following monocondylar arthroplasty depending on the gender, weight of the patient, the etiology of gonarthrosis, the amount of primary deformation of the joint and the state of the bone tissue.

## Material and methods

The materials were reviewed and approved by the local Bioethics Committee at the State Institution Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Medical Sciences of Ukraine (Protocol No. 214 dated 08.04.2021).

The results of the examination of 71 patients (aged from 37 to 83 years) who underwent monocondylar knee arthroplasty at Vinnytsia City Clinical Hospital of Emergency Medical Care from 2010 to 2020 were analyzed. Among the examined were: 21 (29.6 %) men aged (65 ± 9) years, 50 (70.4 %) women aged (64 ± 7) years. There was no age difference between men and women ($p = 0.558$). Unilateral stage 2–3 gonarthrosis was diagnosed in 55 (77.5 %) patients, bilateral stage 2-3 gonarthrosis was determined in 16 (22.5 %).

The period of observation of patients was from 3 to 10 years. During this time, 20 (28.2 %) of them had problems with the operated joint in the form of an increase in the angle of frontal deformation — 8 (40 %), a decrease in mobility — 12 (60 %), pain in the implantation area — 10 (50 %).

The influence of the following factors on the development of instability in the area of implantation was studied: body mass index, a history of injuries to the knee joint (meniscectomy or untreated injury to the menisci, plastic surgery of the cruciate ligament or its old injuries without proper treatment, fractures of the femoral or tibial condyles), the angle frontal deformation, bone density. The mentioned signs of instability are not related to damage to the structural elements of endoprostheses.

Body mass index (BMI) according to Quetelet [8] was determined in patients at the time of presentation with abnormalities of the operated knee joint. Patients were divided into 2 clusters — absence (BMI < 30) and presence of obesity (BMI > 30).

The angle of frontal deformation (varus, valgus) was determined on X-ray images in the frontal plane before endoprosthetic repair, immediately after surgery and in case of complaints [9]. During endoprosthetic repair frontal deformity was eliminated, no cases of residual deformity were recorded.

The density of bone tissue was determined according to the data of dual-energy X-ray absorptiometry (DRA) according to standard protocols for measuring the proximal part of the femur with determination of T-score indicator: over 1 is normal; from –1 to –2.5 — osteopenia, less than –2.5 — osteoporosis. Besides, local osteoporosis was detected by tomography images in patients from the risk group in Hounsfield units [5].

The obtained results of examination and survey of patients were processed statistically. Taking into account the nominal type of data, assessment was carried out by the method of conjugate tables with calculation of the critical value of Pearson's $\chi^2$ and significance of the criterion [10]. Calculations were performed in the IBM SPSS Statistics 20.0 software package (IBM Corp.).

## Results and their discussion

According to the results of assessment, patients were more often diagnosed with unilateral gonarthrosis (77.5 %); bilateral in women was found in 14 (28 %) cases, in men — in 2 (9.5 %) (Table 1).

Assessment of histories showed the presence of injuries to the structures of the knee joint (26.8 % of patients): meniscectomy or injury to meniscus without

surgical intervention, plastic surgery of the cruciate ligament or its old injuries without proper treatment — 15.5 %); fractures of femoral or tibial condyles — 11.3 %. At the time of monocondylar endoprosthetic repair or after it, 35.2 % of patients suffered from obesity: 10 (47.6 %) men, 15 (30.0 %) women, the difference is not statistically significant (p = 0.156) (Table 2).

A history of meniscal injury was statistically significantly (p = 0.010) more frequent in men — 10 (47.6 %) than in women — 9 (18.0 %). Men also underwent meniscectomy more often — 7 versus 2 in women. Cruciate ligament injuries were more common in men — 6 (28.6 %) versus 5 (10.0 %) women (p = 0.048). In 4 (19.0 %) men and 2 (4.0 %) women, cruciate ligament injury was combined with meniscal injury. Fractures of femoral or tibial condyles were found in the history of 8 (11.3 %) patients: men — 1 (4.8 %), women — 7 (14.0 %) cases.

A factor that complicates surgical intervention and its outcome is the frontal deformity of the knee joint (varus or valgus). Deformations that do not exceed 7° are considered a normal angle; larger ones result in a violation of the load distribution on the knee joint, which, in turn, can accelerate the development of degenerative diseases in it. An angular deformation of more than 10° is considered a risk factor for the development of deforming gonarthrosis. The distribution of patients according to the amount of frontal deformation of the knee joint is shown in Table 3, from which we can see that in most of them (39 (54.9%)) the angle of frontal deformation was within 5°–7°; within 7°–10° — in 22 (31.0 %), and more often in men (12 (57.1 %)) than in women (10 (20.0 %)); more than 10° — in 10 (14.1 %), more often observed in women — 8 (16.0 %) versus 2 (9.5 %) in men.

Statistical analysis showed that a decrease in the density of bone tissue occurred more often in women (p = 0.015) than in men. In particular, osteopenia was diagnosed in 33 (66.0%), local osteoporosis — 6 (12.0%) women; in men — 8 (38.1%) and 1 (4.8%), respectively (Table 4).

Complications developed in 20 (28.2 %) patients: 4 (5.6 %) men and 16 (22.5 %) women. But there was no statistically significant difference in the development of complications between men and women (p = 0.268). Thus, further research on the influence of preoperative factors on the development of complications after monocondylar knee arthroplasty will be conducted without taking into account the gender of the patients.

Complications included the appearance or increase of pain syndrome and swelling in the prosthesis area in 10 (50 %) cases, a decrease in the joint movements in 12 (60 %), an increase in frontal deformation of the knee

*Table 1*

**Distribution of unilateral and bilateral gonarthrosis in the studied patients**

| Gender | | Gonarthrosis | |
|---|---|---|---|
| | | unilateral (n = 55) | bilateral (n = 16) |
| Male (n = 21) | abs (%) | 19 (90.5 %) | 2 (9.5 %) |
| Female (n = 50) | abs (%) | 36 (72.0 %) | 14 (28.0 %) |
| Statistical significance of the difference | | $\chi^2$ = 2.892; p = 0.089 | |

*Table 2*

**Distribution of complicating factors in the histories of patients with gonarthrosis**

| Gender | Number of patients | | | |
|---|---|---|---|---|
| | obesity | meniscal injury | cruciate ligament injury | condylar fracture |
| Male (n = 21) | 10 (47.6 %) | 10 (47.6 %) | 6 (28.6 %) | 1 (4.8 %) |
| Female (n = 50) | 15 (30.0 %) | 9 (18.0 %) | 5 (10.0 %) | 7 (14.0 %) |
| Total (n = 71) | 25 (35.2 %) | 19 (26.8 %) | 11 (15.5 %) | 8 (11.3 %) |
| Statistical significance of the difference | $\chi^2$=2.012; p = 0.156 | $\chi^2$ = 6.620; p = 0.010 | $\chi^2$ = 3.896; p = 0.048 | $\chi^2$ = 1.262; p = 0.261 |

*Table 3*

**Distribution of patients according to the amount of frontal knee joint deformity**

| Patient | Angle of frontal deformation (degrees) | | |
|---|---|---|---|
| | 5–7 | 7–10 | > 10 |
| Male (n = 21) | 7 (33.3 %) | 12 (57.1 %) | 2 (9.5 %) |
| Female (n = 50) | 32 (64.0 %) | 10 (20.0 %) | 8 (16.0 %) |
| Total (n = 71) | 39 (54.9 %) | 22 (31.0 %) | 10 (14.1 %) |
| Statistical significance of the difference | $\chi^2$ = 9.557; p = 0.008 | | |

*Table 4*

**Distribution of patients by bone density**

| Patient | Bone density | | |
|---|---|---|---|
| | norm | osteopenia | osteoporosis |
| Male (n = 21) | 12 (57.1 %) | 8 (38.1 %) | 1 (4.8 %) |
| Female (n = 50) | 11 (22.0 %) | 33 (66.0 %) | 6 (12.0 %) |
| Total (n = 71) | 23 (32.4 %) | 41 (57.7 %) | 7 (9.9 %) |
| Statistical significance of the difference | $\chi^2$ = 8.418; p = 0.015 | | |

joint during loads in 8 (40 %) cases. In 3 (15 %) patients, the pain syndrome was combined with limitation of joint mobility and an increase in frontal deformation, and an increase in frontal deformation in 4 (20 %).

Next step involves consideration of the influence of preoperative factors on the development of complications after knee arthroplasty (Table 5).

Thus, the development of complications after endoprosthetic repair was influenced by obesity in 8 (11.3 %) patients, meniscal injury in 7 (9.9 %), cruciate ligaments in 5 (7.0 %), fracture of the femoral and tibial condyles in 2 (2.8 %). The combination of two factors led to complications in 6 (8.5 %) patients, of three in 5 (7.0 %), of four in 2 (2.8 %).

The influence of the frontal deformation angle on the development of complications after arthroplasty is shown in Table 6.

So, according to the analysis, all patients with a pre-surgical deformity angle of more than 10° developed complications within 3 to 10 years, in particular, all of them developed instability of the tibial component of the endoprosthesis. At the same time, in 3 of these patients, complications were accompanied by an increase in the frontal deformation of the knee joint during loads and pain syndrome, in 3, mobility restrictions were additionally noted, in the others, the presence of one symptom of instability of the endoprosthesis was recorded.

Frontal deformation in the range from 7° to 10° in 9 (12.7 %) cases resulted in the formation of instability: in 2 in an increase in the angle of knee deformation, and in 1 with a pain syndrome; in 6 in limitation of mobility in the joint, 2 in pain in the prosthesis area.

At a frontal angle of 5° to 7°, complications developed in only 1 patient in the form of limitation of joint mobility.

The results of the effect of bone tissue density on the development of complications after endoprosthetic repair are shown in Table 7. Complications after knee arthroplasty were found to occur only in patients with reduced bone density, and in the presence of local osteoporosis complications were noted in all patients. In the presence of osteopenia, the risk of complications arose in 13 (18.3 %) patients.

## Discussion

Statistical study on the identification of preoperative factors that can affect the result of monocondylar knee arthroplasty showed that reduced bone mineral density, especially local osteoporosis, is the main aggravating factor. In the presence of osteoporotic zones in the area of endoprosthesis, the risk of endoprosthesis instability can reach 100 %. Frontal deformations of the knee joint over 10° and 5°–7° is an important factor in the development of instability in the postoperative period.

Other factors, such as obesity, injuries to the menisci and cruciate ligaments, fractures of the femoral and tibial condyles do not have a significant impact on the development of instability, but can be a complicating factor with a simultaneous decrease in bone mineral density and/or significant frontal deformity

*Table 5*

**Distribution of risk factors in the histories of patients with complications after arthroplasty**

| Complication | Obesity | Meniscal injury | Cruciate ligament injury | Condylar fracture |
|---|---|---|---|---|
| Without complications (n = 51) | 17 (23.9 %) | 12 (16.9 %) | 6 (8.5 %) | 6 (8.5 %) |
| Complication (n = 20) | 8 (11.3 %) | 7 (9.9 %) | 5 (7.0 %) | 2 (2.8 %) |
| Total | 25 (35.2 %) | 19 (26.8 %) | 11 (15.5 %) | 8 (11.3 %) |
| Statistical significance of the difference | $\chi^2 = 0.280$; p = 0.597 | $\chi^2 = 0.964$; p = 0.326 | $\chi^2 = 1.992$; p = 0.166 | $\chi^2 = 0.045$; p= = ,832 |

*Table 6*

**Distribution of frontal deformity angle values in patients with complications after arthroplasty**

| Complication | Angle of frontal deformation (degrees) | | |
|---|---|---|---|
| | 5–7 | 7–10 | > 10 |
| Without complications (n = 51) | 38 (53.5 %) | 13 (18.3 %) | — |
| Complication (n = 20) | 1 (1.4 %) | 9 (12.7 %) | 10 (14.1 %) |
| Total | 39 (54.9 %) | 22 (31.0 %) | 10 (14.1 %) |
| Statistical significance of the difference | $\chi^2 = 39.901$; p = 0.001 | | |

*Table 7*

**Distribution of bone density values among patients with complications after arthroplasty**

| Gender | Bone density | | |
|---|---|---|---|
| | norm | osteopenia | osteoporosis |
| Without complications (n = 51) | 23 (32.4 %) | 28 (39.4 %) | — |
| Complication (n = 20) | — | 13 (18.3 %) | 7 (9.9 %) |
| Total | 23 (32.4%) | 41 (57.7 %) | 7 (9.9 %) |
| Statistical significance of the difference | $\chi^2 = 27.123$; p = 0.001 | | |

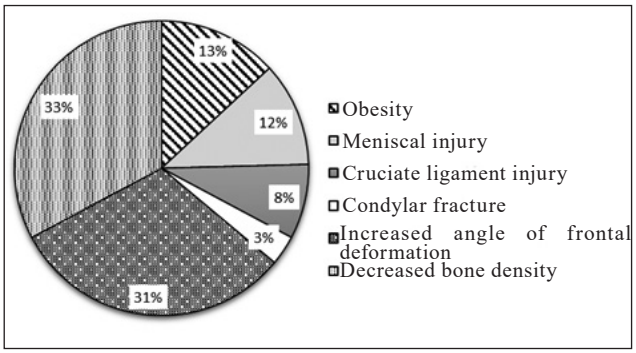


**Figure.** Anatomical and functional factors affecting the development of endoprosthesis instability

of the knee joint. The contribution of each factor to the development of instability of the endoprosthesis component is shown in the Figure.

The identified risk factors for complications after monopolar knee arthroplasty correlate with the data of a meta-analysis, where researchers indicate similar reasons for re-arthroplasty in patients [11]. It is the development of osteoporotic and degenerative changes in the area of arthroplasty that lead to negative consequences and replacement of endoprosthesis components or total arthroplasty.

## Conclusions

Monocondylar endoprosthetic repair of the knee joint is a reliable, cost-effective, low-traumatic method of treating gonarthrosis, but only if clear indications are followed before its implementation. In the remote period after endoprosthetic repair, some patients may develop signs of instability of the endoprosthesis. Significant frontal deformation and reduced bone density (osteoporosis) are aggravating factors for the development of endoprosthesis instability. Combined injuries of the menisci and ligaments of the joint, fractures of the condyles lead to the formation of instability.

The causes of instability in women are more often a frontal deformation angle of more than 10° and a decrease in bone mineral density, and traumatic injuries of the knee joint in men.

Thus, in order to ensure a long-term positive effect after endoprosthetic repair, it is necessary to carefully examine the patient for the presence of certain factors that can lead to instability, and, if possible, eliminate or reduce their influence.

**Conflict of interest. T**he authors declare no conflict of interest.

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# ANATOMICAL AND FUNCTIONAL PREREQUISITES FOR THE DEVELOPMENT OF ENDOPROSTHESIS INSTABILITY AFTER MONOCANDYLAR KNEE ARTHROPLASTY

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