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Residual Deformity after Bilateral Knee Arthroplasty: Impact on Short Term Outcomes

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Abstract

Purpose — to evaluate the impact of frontal positioning of prosthesis components after bilateral TKA on short term functional outcomes.

Material and Methods. The authors performed a retrospective analysis of teleroentgenograms of 466 patients after bilateral TKA with initial varus deformity. Functional and roentgenological outcomes were evaluated at average in 16.4±2.9 months postoperatively. Mean preoperative varus deformity was 10° (from 5 to 25°), initial angle between the anatomical and mechanical femoral axis (FVA) was 6.7±2° (from 3 to 12°). The neutral axis of both lower limbs (HKA = 180±0.5°) was obtained in 99 (21.2%) out of 466 patients.

Residual deformity in one of the limbs above 3° with the neutral alignment of the contralateral limb was observed in 44 (9.4%) patients, bilateral residual deformity – in 32 (6.9%) patients. Other 291 patients demonstrated the deviation from mechanical axis in the range from 1 to 3° (±0.5°).

All patients were divided into three groups: first group consisted of 10 patients with neutral axis of one limb and varus deformity of the other limb above 3°; second group — 10 patients with bilateral residual varus deformity above 3°; third group — 12 patients with neutral axis of both limbs (HKA = 180°). The angle of residual deformity averaged 3.7° (from 3.2 to 5.1°).

Results. No statistically significant differences between the groups were observed for dynamometric parameters and SF-36 scores, as well as for functional KSS scores ($p>0.05$). However, the authors reported in patients of the first group a stance phase on the side of residual varus deformity longer at 15% ($p<0.05$) and transfer phase shorter at 17% ($p<0.05$) as compared to contralateral limb (with neutral alignment, HKA = 180°), which is indicative of load asymmetry and can have a negative impact at a later stage.

Conclusion. Symmetrical residual varus deformity of lower limbs in the rage of 3.2–5.1° has no negative impact of short term clinical and functional outcomes of TKA. Muscular function and gait properties in patients with neutral axis of the lower limbs and in patients with symmetrical residual varus deformity after TKA were similar 16.4±2.9 months postoperatively.

Keywords: knee joint arthroplasty, mechanical axis of the lower limb, varus deformity, gait analysis.

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Introduction

Despite enhancement in surgical techniques and upgrades in orthopaedic implants still up to 20% of patients remain dissatisfied by outcomes of total knee replacement [1].

As known, varus deviation of mechanical axis of the lower limb amounts to 3° and more [2] in 32% of men and 17% of female by the moment they reach skeletal maturity. Full correction of varus deformity during arthroplasty may not be the optimal solution for such patients.

Restoration of the neutral mechanical axis of the lower limb is conventionally considered as one of the criteria for successful outcome of TKA, while deviation of prosthesis components from mechanical axis of ±3° is believed by many specialist to be the golden standard of joint replacement [3–5].

Disputes on tolerance of keeping residual varus axis deformity after TKA on are not ceasing. Some authors insist on a need for full deformity correction [3, 6–11], others disprove this option by demonstrating absence of differences in TKA outcomes in patients with full varus correction and in patients with residual deformity [12–15].

T. Luickx et al. [16] evaluated teleroentgenograms of 456 patients after TKA and observed residual varus of >3° in 39.8% of patients. At the same time the involuntary incomplete correction was proportional to initial varus deformity and was mainly conditioned by varus positioning of tibial and femoral components.

Recently a theory is becoming increasingly popular which suggests that restoration of neutral mechanical axis doesn't guarantee the excellent outcome of TKA. The advocates of kinematic orientation of prosthesis components added fuel to the flames while by inserting femoral component with 3° of varus and preserving at the same time internal rotation of the distal femur, they ruin the classical concept of components orientation and gain outcomes comparable or superior to outcomes following the conventional technique [17].

The issue of residual varus impact on outcomes of unilateral TKA is well elaborated in the literature, however, no publications were found on this topic following bilateral TKA. Thus, the authors dedicated the present research to this problem.

Purpose of the study — to evaluate the impact of frontal positioning of prosthesis components during bilateral TKA on short-term functional outcomes.

Material and Methods

The authors performed a retrospective analysis of teleroentgenograms of 466 patients after bilateral TKA with initial varus deformity. All patients were operated at the same institution (Ural clinical surgical and rehabilitation center, Nizhny Tagil) from September 2014 till August 2016.

Teleroentgenography of lower limbs allows to evaluate the frontal positioning of components as precise as digital computer tomography, however, it gives significantly poorer results than CT in respect of precision in identifying components orientations in sagittal and horizontal planes [18, 19]. That's why having the X-ray data base of all patients who were operated and followed up after arthroplasty in our center, the authors decided to evaluate only the AP x-rays. Teleroentgenograms were analyzed according to the method of A. Durandet et al. [20] using VEPRO software ver.8.2 (Germany) (Fig. 1).

The authors assessed:

– overall deformity;

– angle between the center of the femoral head and centers of knee and ankle joint (HKA);

– angle between anatomical and mechanical axis of femur (FVA);

– lateral distal femoral angle (LDFA);

– medial proximal tibial angle (MPTA).

The authors also performed a clinical evaluation of treatment outcomes and functional status of the muscles (tibia flexors and extensors) using multi-joint treatment and diagnostics device Biodex Systems 4 Quick-Set (USA).

Qualitative gait criteria were evaluated on hard and software equipment DIERS 4D motion Lab (Germany).

The following inclusion and exclusion criteria were applied to make patient groups more homogeneous.

Inclusion criteria:

1) idiopathic bilateral knee arthrosis of grade 3 according to N.S. Kosinskaya with initial varus deformity within 5–18°;

2) middle or elderly age of patients (from 44 to 75 years according to age periodization of World Health Organization dated 2016);

3) normal bone mass or grade 1 obesity (BMI from 18.5 to 35) [21];

4) cemented prosthesis with posterior stabilizer Stryker NRG PS (USA) with a single radius femoral component without replacement of patella surface.

Exclusion criteria:

1) systemic diseases of connective tissues, metabolic disorders, osteopenia or osteoporosis (T-criteria — 1,5 and less [22]);

2) postoperative complications: infections, vascular and mechanical (periprosthetic fractures due to high energy trauma);

3) previous history of lower limb bone fractures;

4) comorbidity index M.E. Charlson above 3 [23].

Patients were divided into three groups:

– 1st group (asymmetric) — residual varus deformity of one limb with a neutral alignment of contralateral limb (10 patients);

– 2nd group (symmetric) — bilateral residual varus deformity (10 patients);

– 3rd group (neutral) — neutral axis of both lower limbs (HKA = 180°) after TKA (12 patients).

All patients were comparable in terms of gender, age, BMI (Table 1).

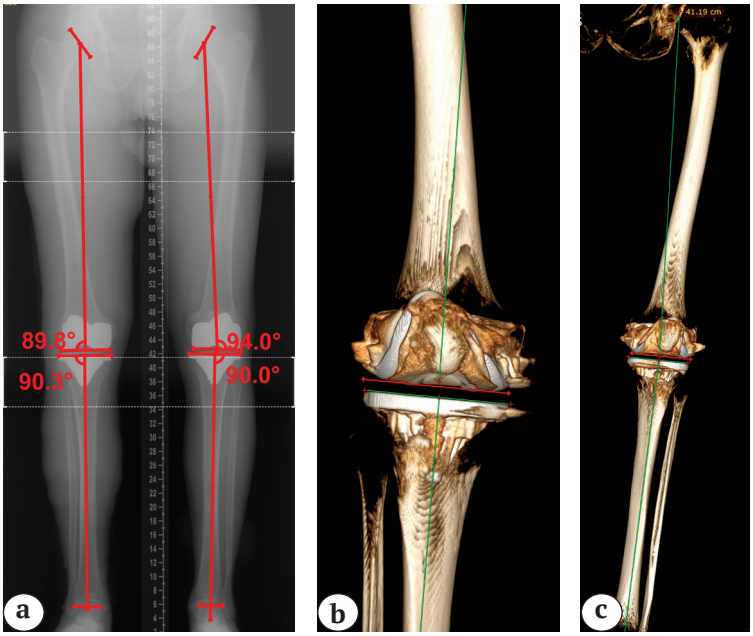

Fig. 1. Teleroentgenogram of lower limbs: neutral alignment of the right leg and reamining 4° varus deformity of the left leg is relation to the mechanical axis (a); CT scans of lower limbs with 3D-reconstruction after TKA in the same patient (longitudonal green line indicates mechanical axis on both sides, red line — LDFA, transverse green line — MPTA) (b, c)

Table 1

Comparative criteria of study groups of patients

Criteria	Group		
	1st asymmetric	2nd symmetric	3rd neutral
Gender, male/female	2/8	1/9	2/10
Mean age, years	65,2±6,3	64,8±4,3	64,3±4,1
Mean BMI	30,2±4,4	30,4±4,1	30,6±2,1

p>0,05.

Correct horizontal and sagittal positioning of components in all patients was confirmed by computer tomography with 3D-reconstruction on Siemens Definition AS 64 apparatus according to the knee joint examination protocol after total replacement [24] (Fig. 2).

Functional and roentgenological outcomes were evaluated in 12–26 months after the last surgery. Life quality was assessed by SF-36 questionnaire [25].

Knee Society Score (KSS) was used for overall evaluation of knee joint function [26].

Biodex Systems 4 Quick-Set (USA) was used for dynamometric examination in isokinetic mode at speed of 180°/sec. [12, 27]. The authors evaluated the following criteria (in %):

– torque/body mass — ratio of the maximum torque to the body mass of the examined patient (criteria designates muscular force);

– activity fatique — ratio of activity during first and third periods of study (criteria designates muscular endurance);

– ratio of peak torque to antagonistic muscles (tibia flexors/extensors).

Gait was evaluated by dynamic stabilometry using DIERS 4D motion Lab (Germany).

Examination method. A 1 m long metering skid with gauges for precise estimation of pressure values was integrated into the running track. Following the instructions for use from manufacturer, light-reflecting markers were fixed to the body of the patient and patient was walking on the running track. Values were registered at the speed of 2,5 km/h with overall passed distance of 20 m (Fig. 3).

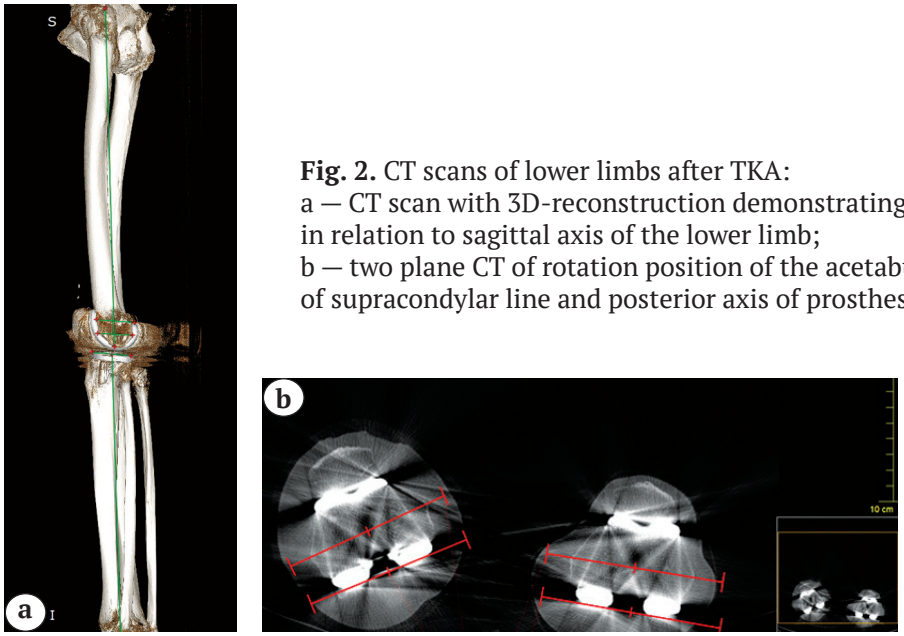

Fig. 2. CT scans of lower limbs after TKA:
a — CT scan with 3D-reconstruction demonstrating positioning of components in relation to sagittal axis of the lower limb;
b — two plane CT of rotation position of the acetabular component with aid of supracondylar line and posterior axis of prosthesis

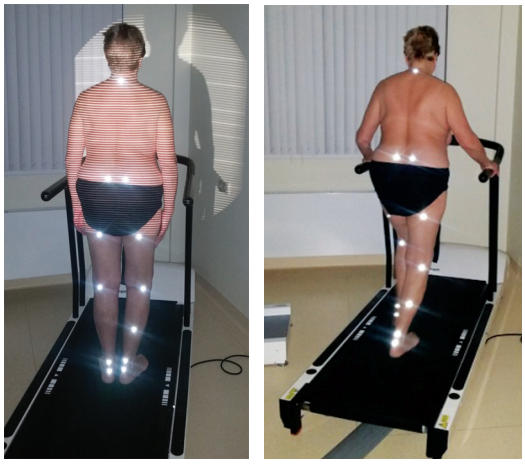

Fig. 3. Gait assessment using DIERS 4D motion Lab system

Statistical analysis. Obtained digital data was statistically processed based on Fisher's ratio test and Mann Whitney U-test and using software StatSoft Statistica 6.0.

Results

Teleroentgenograms analysis of 466 patients demonstrated that varus deformity prior to surgery averaged to 10° (from 5 to 25°), the initial angle between anatomical and mechanical axis of the femur (FVA) was 6.7±2° (from 3 to 12°).

After TKA the neutral axis of both lower limbs (HKA = 180±0.5°) was obtained in 99 (21.2%) patients. Residual deformity above 3° of one limb with the neutral axis of contralateral limb was reported in 44 (9.4%) patients, bilateral residual deformity of both lower limbs above 3° was in 32 (6.9%) patients. In other 291 patients deviation from mechanical axis was within 1 до 3°. Residual deformity angle averaged to 3.7° (from 3.2 to 5.1°).

In the 1st group the unilateral deformity due to varus positioning of femoral component (LDFA) was reported in 5 (50%) cases. Overall combined deformity above 3° due to distal femoral and proximal tibial angles (MPTA) which means varus positioning of both components of prosthesis was observed in 4 (40%) cases. Isolated residual deformity of tibial component (MPTA) was reported in one case (10%).

In the 2nd group the unilateral varus deformity due to distal femoral angle (LDFA) was reported in 7 (35%) cases, and combined residual deformity in 10 (50%) cases. In 3 (15%) patients residual deformity resulted from varus positioning of tibial component. Subjective assessment of psychological and physical health of patients by SF-36 survey did not reveal any statistically significant variances between the groups (p>0.05) (Table 2).

Table 2

SF-36 Quality of life assessment, scores

Subscale SF-36	Group		
	1st asymmetric	2nd symmetric	3rd neutral
Physical functioning (PF)	61,4±12,6	63,8±10,6	63,2±9,4
Role physical Functioning (RP)	59,2±6,9	57,4±6,0	56,4±7,7
Pain (P)	60,2±10,1	64,2±6,6	64,0±12,8
General Health (GH)	76,0±6,4	74,0±10,1	76,3±13,8
Vitality (VT)	62,6±4,7	61,8±8,4	63,9±8,0
Social Functioning (SF)	78,2±3,4	78,4±9,2	78,5±8,6
Role Emotional (RE)	64,4±4,8	62,1±9,2	68,4±5,5
Mental health (MH)	78,6±6,2	78,4±6,0	80,4±8,2

p>0,05.

Knee function assessment by Knee Society Score (KSS) provided the following results: 1st group — 90.5±6,0 points, 2nd group — 91.8±8.4, 3rd group — 92.5±7.6 points (p>0.05).

Functional assessment of flexion-extension complex of the knee joint after bilateral TKA did not demonstrate any significant variances. Isometric and isokinetic parameters in all groups did not give any statistically significant differences (p>0.05). Evaluation results of static-dynamic function of the lower limbs after bilateral TKA on Biodex Systems 4 Quik Set are given in Table 3.

Bilateral assessment of the gait did not provide any statistically significant variances between criteria of dynamic stabilometry in the 2nd and 3rd group (p>0.05). At the same time patients of the 1st group demonstrated a statistically significant increase of single rest period (35.1±4.4) and decrease of transfer period (30.4±6.4) at the limb with residual varus deformity in contrast to contralateral limb (neutral alignment, HKA = 180°) — 31.4±6.2 and 36.9±5.5 respectively (p<0.05). This can indicate the higher load on limb with deformity during walking and possibly result in earlier wear of prosthesis components as compared to contralateral limb. Thus, the signs of so called latent limping were observed in patients of the 1st group, whereby the signs are not manifesting during short-term period (Table 4).

Table 3

Results of static and dynamic function assessment of the lower limb on Biodex Systems 4 Quik Set

Dynamogram parameters		Group			
		1st asymmetric		2nd symmetric	3rd neutral
		RV	NA	RV	NA
Torque/bone mass , %	flexion	84,6±6,9	81,4±11,6	**84,4±12,2** 84,8±10,1	**82,2±17,6** 80,8±12,3
	extension	64,6±18,1	62,6±14,4	**68,2±16,4** 72,4±8,1	**71,4±11,9** 74,6±8,8
Peak torque of antagonistic muscles ratio		39,4±7,7	37,6±8,8	**39,2±7,0** 46,8±3,3	**37,4±7,0** 44,6±6,9
Activity fatique, %	flexion	20,2±4,0	21,4±9,2	**20,4±8,0** 20,4±8,1	**20,2±4,4** 18,4±10,9
	extension	22,2±6,1	21,0±6,6	**26,3±4,8** 23,6±2,9	**24,2±6,4** 22,4±6,3

RV — residual varus deformity, NA — neutral axis.
The bold type indicates the movement amplitude of the extremity operated in the second place.
p>0,05.

Table 4

Results of dynamic stabilometry

Группа		Параметр						
		Rest period, %	1st period of double rest, %	Single rest period, %	2nd period of double rest, %	Transfer period, %	Period of double rest, %	Step time (sec)
1st asymmetric	NA	64,4±3,1	16,0±4,4	31,4±6,2*	15,1±3,8	36,9±5,5*	32,1±6,0	1,2±0,3
	RV	66,6±6,1	15,2±3,5	35,1±4,4*	15,0±3,4	30,4±6,4*	30,1±3,8	1,1±0,1
2nd symmetric		**65,8±3,8** 65,8±3,0	**16,1±3,2** 15,6±2,2	**34,0±3,1** 30,1±3,4	**15,0±2,2** 15,0±4,4	**34,6±4,9** 32,2±4,0	**34,0±3,1** 34,0±1,2	**1,1±0,1** 1,0±0,3
3rd neutral		**64,1±4,2** 64,2±4,7	**15,5±2,7** 16,1±1,8	**33,7±1,6** 34,5±2,0	**18,7±2,4** 16,7±3,4	**34,4±3,1** 33,1±2,7	**34,4±1,8** 36,1±0,4	**1,2±0,2** 1,2±0,4

RV — residual varus deformity, NA — neutral axis.
The bold type indicates the movement amplitude of the extremity operated in the second place.
p>0,05.

Discussion

Analysis of teleroentgenograms demonstrated that the angle between anatomical and mechanical axis of the femur (FVA) prior to surgery averaged to 6.7±2.0° (от 3 до 10°). The authors examined only patients with varus deformity.

As of A.B. Mullaji et al. FVA >7° is usually observed in 44,9% of people, and <5° — in 10.9%. Consequently, use of fixed FVA of 5°, 6° or 7° during surgery (without prior determining of FVA on teleroentgenograms) the deviation from neutral axis of >2° will occur in 45.1%, 28.2%, or 21.1% of people respectively [28].

Deviation from neutral axis in TKA might occur also during cementing procedure. Thus, D.F. Howie et al. observed that 2° deviation from neutral axis between measurements on test and final components of prosthesis took place in 14% of cases with use of computer navigation [29].

G. Matziolis et al. compared functional status of knee joint by KSS, WOMAC and SF-36 scales in patients with neutral axis and residual varus deformity of the lower limb (≈6.3°) after TKA and reported no difference in 5 years postoperatively [30]. M.M. Allen et al. also did not establish any impact of residual varus deformity on functional outcome and prosthesis survivorship during 15 years after the surgery [31]. However, R.A. Magnussen et al. consider that KSS scores in patients with residual varus deformity are better than in patients with neutral axis of the lower limbs after TKA [32]. J. Stucinskas et al. evaluated TKA outcomes in patients with residual varus and valgus deformity one year postoperatively basing on standard assessment methods supplemented by dynamometry. No statistically significant differences were observed as compared to neutrally aligned limb (HKA — 180±3°) [33]. However, there are absolutely controversial opinions in respect of frontal alignment [4, 5, 34].

All above mentioned papers present outcomes of unilateral knee replacement The authors of the present paper reflected outcomes of bilateral alignment of the lower limbs axis in patients with knee arthrosis. 3rd group included the patients only with the neutral axis of lower limbs (HKA = 180°) with accuracy up to 0.5°.

However, according to the literature the tolerated deviation value is no more than 3° [3–5]. For this reason, 1st and 2nd groups included patients with deformity above 3° which was con-

sidered as residual deformity. The authors did not reveal statistically significant differences between residual deformity and neutral axis after TKA in the short term after bilateral replacement in symmetrical groups. However, in patients of the 1st group the authors observed on the side with residual deformity the increased period of single rest at 15% ($p<0.05$) and decreased transfer period at 17% ($p<0.05$) as compared to contralateral limb (neutral axis alignment, HKA = 180°). Patients of the 2nd and 3rd groups (with symmetric varus deformity and bilateral neutral axis of the lower limbs after TKA) demonstrated similar clinical and functional outcomes in the short term after the surgery. This allows suggesting that residual varus deformity after TKA does not affect the outcomes in case of deformity symmetry.

The winning formula for knee joint replacement is still to be found. A great number of patients who underwent canonical TKA consider the outcomes of their surgery as controversial or unsatisfactory. All of above urges us to continue the search for solution of this issue.

Symmetric residual varus deformity of the lower limbs of 3.2–5,1° doesn't negatively affect short term clinical and functional outcomes of TKA. Muscles function and gait quality of patients with neutral axis of lower limbs and symmetric residual varus deformity are similar in 16.4±2.9 months after TKA.

Asymmetric residual varus deformity in 16.4±2.9 months after TKA is manifesting through increased period of rest at 15% ($p<0.05$) and decreased transfer period at 17% ($p<0.05$) on the limb with residual deformity as compared to contralateral limb (neutral alignment, HKA = 180°).

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