

REVIEW

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Subject: defence of the dissertation of **Dr. Veselin Vladislavov Grigorov**,
entitled

“Planning in Total Knee Arthroplasty”

for the award of the educational and scientific degree “Doctor” (PhD).

By Order of the Rector of Medical University – Varna No. R-109-287/03.08.2026, I was appointed a member of the Scientific Jury, and by decision of the latter (Protocol No. 1 of 10.08.2026) I was designated to present a review of the dissertation of **Dr. Veselin Vladislavov Grigorov**, a full-time PhD student at the Department of Orthopaedics and Traumatology, Faculty of Medicine, Medical University – Varna, in higher education area 7. “Health Care and Sports”, professional field 7.1 “Medicine”, doctoral programme “Orthopaedics and Traumatology”.

Knee arthroplasty is one of the most frequently performed orthopaedic operations. Failure, however, sometimes leads to a 30% permanent reduction in working capacity. Given this high frequency, substantial changes in design, materials, surgical technique and perioperative care are required in order to increase implant survival and reduce the number

and frequency of complications. In recent years, quite promising progress has been made in this respect. Nevertheless, patient satisfaction with the outcome of knee arthroplasty still cannot match that of hip arthroplasty. The causes of this unsatisfactory outcome may be sought in implant-related, surgical-technique-related or patient-related factors.

Planning of the surgical procedure – total knee arthroplasty – and the different approaches to knee alignment constitute the main line of analysis both in contemporary research and in the present dissertation.

There are different approaches to the design of modern knee arthroplasty implants and to their application. The extent to which the anatomical features of each individual's lower limb are taken into account differs between these approaches. This leads to excessive "alignment" of the limb axis, which was not characteristic of the patient and may result in functional imbalance and unsatisfactory subjective outcomes, despite an impeccably planned and performed surgical intervention as assessed by postoperative radiographic criteria.

This is precisely where a serious study has its place – one that, by analysing the two main approaches to total knee arthroplasty, attempts to answer the questions of whether surgical treatment with a custom-made implant and three-dimensional computed-tomography planning, or computer-navigated arthroplasty with restricted kinematic alignment, will yield better clinical and functional outcomes over time, and whether this analysis will provide sufficiently reliable statistical conclusions that would be of benefit to our orthopaedic community.

The problem addressed in the dissertation is therefore highly topical, and the assessment of postoperative axial alignment, accuracy relative to the plan, the rate of outliers according to a criterion consistent with restricted kinematic alignment, component positioning, operative time, functional outcomes (OKS, VAS, ROM), complications and revisions would lend sufficient scientific and practical weight to the study. Preoperative computed tomography involves a certain radiation exposure, as well as implant manufacturing time and cost; navigation, on the other hand, requires setup time.

These are the questions that the dissertation submitted for defence by Dr. Grigorov addresses. It is a retrospective–prospective comparative clinical study including patients who met strict indications.

The functional outcomes of 60 patients in two study groups of equal size (30 per group) are analysed. The first group underwent individualised TKA with three-dimensional CT-based preoperative planning using KNEE-PLAN® software; the second group underwent computer-navigated TKA with OrthoPilot® intraoperative navigation applying restricted kinematic alignment, which allows up to 5° of varus–valgus deviation from the neutral axis with the aim of restoring the natural kinematics of the knee joint.

The dissertation follows the customary structure for this type of work and comprises 101 standard pages, with 12 tables and 23 figures, all numbered and titled in Bulgarian. The figures are of high quality and informative value and correspond in meaning to the accompanying text. The dissertation has three appendices used in the course of the work, as well as a Postoperative Questionnaire.

In the remaining part of the dissertation, Dr. Grigorov sets out the aim and the eight objectives arising from it, the study population, the clinical methodology of the study, the techniques used for patient assessment, his own results, the author's analysis and the conclusions. The bibliography includes 212 references, 2 in Cyrillic and 210 in Latin script.

The literature review is sufficiently extensive and covers all aspects of the problem. Predominantly recent publications are presented, most of them from the last 5 years. The cited sources are from reputable scientific journals. The review comprises 50 pages and represents 40% of the volume of the dissertation. It successively presents:

Bone anatomy and capsuloligamentous anatomy – the shape, structure and insertions to adjacent anatomical structures are discussed, as well as the static stability of the knee joint, the medial and lateral ligamentous complexes, which represent thickenings of the capsule, the bony landmarks, the ligamentous structures and soft-tissue balance.

Consideration is given to the values of the distal femoral angle; the anterior femoral bow; the position of the transepicondylar axis; the surgical transepicondylar axis as a more reliable indicator of rotational alignment, lying at approximately 3° of external rotation relative to the posterior condylar line; the difference in morphology between the two tibial plateaus; the values of the tibial slope in the sagittal plane, which plays an important role in knee kinematics; the medial proximal tibial angle; tibial torsion; and the role of the patella in increasing the lever arm of the extensor mechanism and improving quadriceps efficiency. All of these elements are fundamental to the planning of total knee arthroplasty.

The articular and ligamentous structures stabilising the knee are discussed, in particular the role of the medial collateral ligament, which is the primary restraint to valgus stress in the knee joint.

Biomechanics of the knee joint – higher demands for specific activities of daily living are identified. Knowledge of these characteristics is important for planning surgical procedures and for restoring joint mechanics as close to normal as possible. The difference between the conventional and the computer-navigated technique for the femoral cut is noted – compensation for the varus angle on the one hand, and automatic manipulation on the other. The different phases of flexion and extension are analysed kinematically, highlighting the effect of the loss of the screw-home mechanism – the “locking” of the knee joint in extension that ensures its stability during standing – in most modern total knee arthroplasty implants. From the distribution of load in the knee joint during daily activities it is evident that even small deviations in axial alignment can lead to significant changes in load distribution and accelerated wear of the polyethylene insert.

Aetiology and pathogenesis – Osteoarthritis is no longer regarded simply as “wear and tear” of cartilage, but as a complex disease of the whole joint involving cartilage, subchondral bone, synovium, ligaments, menisci and periarticular muscles.

Radiographic classification. The Ahlbäck classification (1968), modified by Keyes (1992), is a commonly used system that focuses on joint space narrowing. It divides OA into five grades (from joint space narrowing to lateral tibial subluxation) and is particularly popular in the Scandinavian countries.

Treatment – The indications for total knee arthroplasty are presented in relation to prior history, treatment and age.

The main alignment concepts in total knee arthroplasty are set out: **mechanical alignment** – the most standardised technique, easy to teach and reproduce, but altering the patient’s native anatomy, which may lead to changes in soft-tissue balance and an unnatural feel of the joint; **kinematic alignment** – achieved by positioning the implant components so that they match the patient’s individual pre-arthritic anatomy.

Here one of the most topical, contemporary and debated themes of the dissertation, underlying the main study, becomes evident – the consideration of the alignment concept as directly linked to preoperative planning: while mechanical alignment can be achieved with

relatively standardised 2D planning, kinematic alignment requires 3D CT planning or intraoperative computer navigation. In any case, preoperative planning is regarded as an integral part of the preparation for total knee arthroplasty and aims to determine the optimal size, position and orientation of the implants for each individual patient.

After a precise description of the two types of planning, the PhD candidate highlights the advantages of 3D planning, one of the most important being the ability to measure femoral and tibial rotational parameters directly. Patient-specific instrumentation, the principles of its use and the clinical outcomes obtained with it – advantages and disadvantages – are described and analysed.

The essence and working principles of computer-navigated surgery in total knee arthroplasty are discussed – the position and orientation of the surgical instruments and bone cuts are tracked and verified in real time using a computer system – with its advantages and disadvantages again highlighted.

In describing the most advanced approach – robotic surgery in total knee arthroplasty – the PhD candidate reviews its classification and addresses the direct comparisons between robotic and navigated techniques in total knee arthroplasty, which are still limited.

The literature review is focused on the dissertation and represents a critical synthesis of Dr. Grigorov's extensive knowledge of the problem – a comparative evaluation of the three main approaches to planning and performing total knee arthroplasty: conventional 2D preoperative planning with manual instrumentation, 3D CT-based preoperative planning (with or without patient-specific instrumentation), and intraoperative computer navigation. Each of these approaches has a specific profile of advantages and limitations, and the choice between them depends on multiple factors. After a thorough analysis of the literature, the PhD candidate concludes that long-term registry data consistently show an advantage of navigated total knee arthroplasty with respect to revision rate, especially in younger patients. This finding supports the hypothesis that improved alignment translates into a clinically meaningful advantage over time, as malaligned implants are subjected to the cumulative effect of increased and asymmetric loading.

The aim set for the PhD candidate is formulated in **Chapter II**: “To perform a comparative analysis of the accuracy of the achieved axial alignment and of the early clinical and functional outcomes of two contemporary approaches to total knee arthroplasty (TKA):

individualised TKA with three-dimensional preoperative planning, on the one hand, and **computer-navigated TKA using a navigation platform with restricted kinematic alignment (rKA)**, on the other.”

The main thesis is that the navigated approach with an off-the-shelf implant can achieve comparable functional outcomes with lower radiation exposure, lower cost and a shorter logistical pathway for the patient.

In view of the stated aim, **8 scientific objectives** are formulated. They are logically justified, follow from the stated aim and are realistically achievable.

Chapter III, comprising 6 pages, presents the clinical material and the methods used. A retrospective–prospective comparative study was conducted. Two groups of patients who underwent total knee arthroplasty by two different methods were included and compared with respect to radiographic alignment parameters and clinical and functional outcomes. The study covers the period 2019–2024 and was carried out at the Clinic of Orthopaedics and Traumatology, University Multiprofile Hospital for Active Treatment “St. Marina” – Varna. Patients meeting the inclusion criteria were divided into two groups of equal size (30 knees per group):

Group “1”: Individualised TKA (IND, n = 30 knees): Symbios Origin® implant (CIM), three-dimensional CT-based preoperative planning using KNEE-PLAN® software, single-use patient-specific instrumentation and personalised alignment (Origin Alignment©).

Group “2”: Computer-navigated TKA (NAV, n = 30 knees): standard BBraun Columbus® implant, OrthoPilot® intraoperative navigation applying restricted kinematic alignment (rKA), allowing up to 5° of varus–valgus deviation from the neutral axis with the aim of restoring the natural kinematics of the knee joint.

The two surgical techniques used in the two patient groups are described – in **Group 1** by positioning the patient-specific cutting guides according to the preoperative three-dimensional plan, and in **Group 2** by means of navigation-controlled cutting blocks with real-time verification of each resection. In **Group 1**, preoperative planning was performed on a three-dimensional computed-tomography model of the limb using KNEE-PLAN® software, on the basis of which the custom implant and the patient-specific instrumentation were manufactured. In **Group 2**, the target alignment was set intraoperatively using the OrthoPilot® navigation system, which registers the anatomical landmarks and calculates the

axes in real time, with execution controlled according to the principles of restricted kinematic alignment.

Descriptive and analytical statistical methods were used. Qualitative variables were presented as frequencies and percentages. Normality of distributions was tested with the Shapiro–Wilk test. Between-group comparisons of quantitative variables were performed with the independent Student’s t-test (for normally distributed data) or the Mann–Whitney test; qualitative variables – with the χ^2 test or Fisher’s exact test; when expected cell frequencies were below 5, multi-category distributions were collapsed into dichotomous ones and Fisher’s exact test was applied. Within-group preoperative–postoperative comparisons were performed with the paired t-test or the Wilcoxon test. Effect size measures were also calculated (Cohen’s d; rank-biserial coefficient r). The threshold for statistical significance was $\alpha = 0.05$. Analysis was performed in Python (SciPy).

The results of the study are correctly presented in **Chapter IV**. They comprise 15 pages and are supported by highly informative figures and graphs.

Descriptive methods are used to present data on baseline characteristics, axial alignment, functional outcomes, operative time, secondary radiographic parameters and complications.

The two groups differ substantially in both parameters: the individualised group is younger (60.7 ± 9.5 vs. 68.7 ± 9.0 years), and its follow-up period is several times longer (median 72 vs. 12 months). Postoperative axial alignment is comparable between the two groups. The analysis quantitatively confirms the intended difference between the two alignment philosophies: the personalised custom-made implant reproduces the patient’s own axis, whereas restricted kinematic alignment corrects it towards the neutral axis within permitted limits. For the functional parameters, between-group effects are small, whereas within-group changes show large effect sizes and high significance. Comparing the agreement between planned and achieved values (NAV group), the analysis finds that the deviation for the various parameters is within the range (-0.57 to $+0.61$).

No treatment-related complications were observed, although the follow-up periods of the two groups differ.

The following **Chapter V**, comprising 5 pages, presents the **discussion** of the dissertation. Here the author’s own results are presented, compared with and supported by literature data. This chapter is the most creative part of the entire work. It convincingly demonstrates Dr. Grigorov’s expertise in the subject, as well as his understanding of the shortcomings of his own study.

He begins by discussing the finding that the two methods achieve comparable early functional outcomes and comparable accuracy of axial alignment, with a significant advantage of the individualised approach in terms of operative time and an advantage of the navigated approach in terms of radiation exposure and cost. This finding is consistent with the working hypothesis and supports the thesis that comparable clinical outcomes can also be achieved with a lower-cost off-the-shelf implant, while both methods perform successfully with respect to the target and patient satisfaction – not by approximating a strict neutral axis, but through a controlled restoration of the constitutional axis. In comparing the literature data, Dr. Grigorov notes a discrepancy due to the retrospective nature of the analysis – preoperative data were not documented but were recorded through patient recall in a telephone interview. This, however, does not diminish the value of the dissertation. The PhD candidate describes the limitations of the study very precisely – the difference in follow-up periods; the analysis at the knee level, whereby bilaterally operated patients introduce within-patient dependence; and the single-centre design, which limits generalisability – while at the same time showing that he is clear about the future directions of his work.

The conclusions of the discussion are set out in **Chapter VI**. The analysis arrives at several conclusions with which I fully agree. The most significant of them is the first: the achieved postoperative axial alignment (HKA) is comparable between individualised and navigated TKA, with no statistically significant difference.

Second, both methods provide high accuracy of execution relative to the preoperative/intraoperative plan, with virtually complete agreement in the individualised approach. Third, with comparable functional outcomes, the navigated approach with an off-the-shelf implant offers advantages in terms of radiation exposure and cost, which supports the main thesis of the dissertation.

The following contributions can be noted, grouped as:

Original contributions:

1. For the first time in Bulgaria, a direct comparison has been performed between individualised TKA with a custom-made implant and three-dimensional computed-tomography planning and computer-navigated TKA with restricted kinematic alignment, within a single methodology, by a single surgical team and at a single clinical centre.

2. The learning curve in navigated TKA has been documented and quantified using regression, rank-correlation and CUSUM analysis, as has the absence of such a curve with the individualised approach.

Confirmatory contributions

1. The comparability of early functional outcomes between contemporary alignment algorithms has been confirmed, with marked within-group improvement in both groups.

Practical and applied contributions

1. The applicability of navigated TKA with restricted kinematic alignment and an off-the-shelf implant as a resource-efficient alternative with comparable early functional outcomes has been substantiated;

2. Recommendations for clinical practice have been formulated, taking into account not only alignment accuracy but also the overall resource profile of the method.

3. The identified inflection point of the learning curve at around the tenth case provides a practical benchmark for institutions introducing navigated arthroplasty.

4. Bulgarian-language preoperative and postoperative questionnaires for recording OKS and VAS have been developed and implemented.

On the dissertation topic, Dr. Grigorov presents 3 publications (all of which meet the criteria for genuine publications). They are published in peer-reviewed journals meeting the minimum requirements for Area 7. Health Care and Sports, in accordance with the 2018 Regulations for the Implementation of the Act on the Development of the Academic Staff in the Republic of Bulgaria. They contain separate parts of the developed material.

The Abstract (Autoreferat) of the dissertation submitted to me comprises 25 pages and is prepared in accordance with the requirements of Appendix No. 8 of the Regulations on the Terms and Procedure for Acquiring Scientific Degrees and Holding Academic Positions at Medical University – Varna.

In **conclusion**, the dissertation submitted for my review demonstrates the candidate's ability to formulate a scientific thesis and a methodology for addressing it, to select and

process material, and to draw statistically reliable conclusions on a topical and specific subject – **“Planning in Total Knee Arthroplasty”**.

The dissertation fully meets the qualitative and quantitative criteria set out in the Requirements for a Dissertation for the Award of the Educational and Scientific Degree “Doctor” at Medical University – Varna. For this reason, and in view of the fact that virtually all of the clinical work presented was carried out by Dr. Grigorov personally, I give a positive assessment of the work and call upon the members of the Scientific Jury to award **Dr. Veselin Vladislavov Grigorov** the educational and scientific degree “DOCTOR” (PhD) in the scientific specialty “Orthopaedics and Traumatology”.

Заличено на основание чл. 5,
§1, б. „В“ от Регламент (ЕС)
2016/679

30.09.2026,
Sofia

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