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Original article

NAVIGATED TOTAL KNEE REPLACEMENT - OUR PHYSIOTHERAPY EXPERIENCE IN THE EARLY POSTOPERATIVE PERIOD

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ABSTRACT:

The advancement of technology has led to the development of surgical instruments that aim to assist and improve surgical skills and patient satisfaction after operation. One of the most significant advancements in this field has been the introduction of navigation systems for knee arthroplasty. Computer-assisted orthopedic surgery and navigation applications work towards fusing images with anatomical landmarks in real-time. In addition to being an educational tool for less experienced surgeons, this technology also assists experienced surgeons in planning bone cuts, tunneling, and ligament balancing.

Purpose: This study explores the potential benefits of physical therapy methods for patients who have undergone Navigated total knee replacement.

Material/Methods: The study comprised ten patients of both sexes aged between 18 and 80 years with an assisted total knee arthroplasty who fulfilled the specified inclusion criteria. The patients underwent navigated total knee arthroplasty, which resulted in postoperative contracture and oedema. Patients are followed up at three-time points and assessed using a knee injury and osteoarthritis outcome score questionnaire, circumference measurements, range of motion and a pain rating scale (visual analogue scale).

Results: A significant improvement has been observed in reducing girth measurements and pain rating scale, as measured by (VAS), increase in ROM and a decrease in contracture.

Conclusions: Combining the surgical technological revolution with the potential of restorative physical therapy methods is essential for achieving sustainable and fast results.

Keywords: navigation systems for knee arthroplasty, total knee replacement, kinesitherapy, deep oscillation therapy,

INTRODUCTION

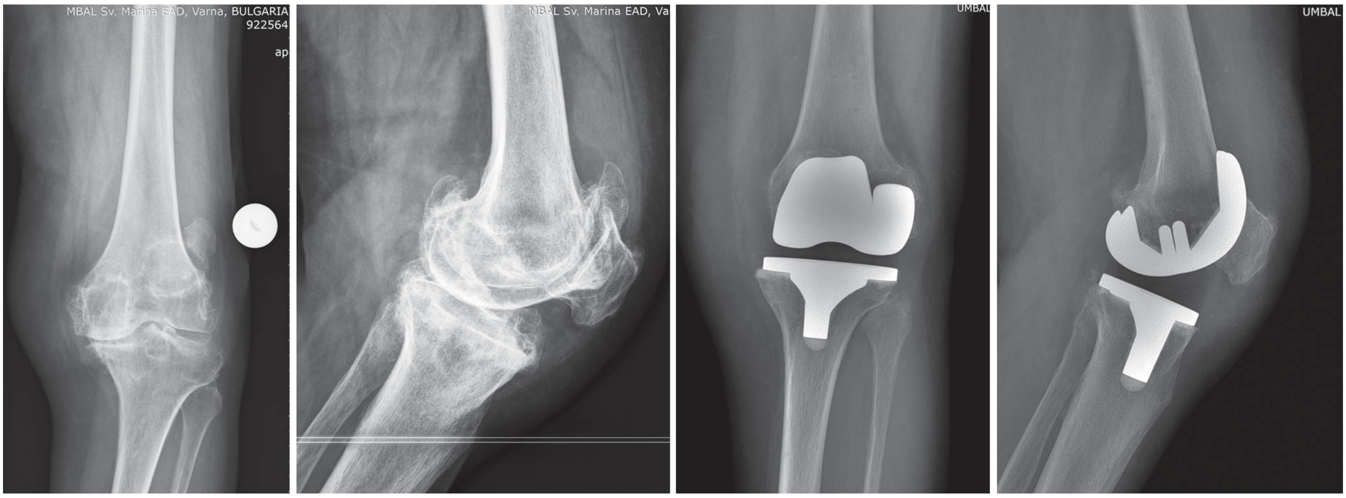
Extremity fractures are associated with a high prevalence and significant socioeconomic burden due to loss of work and treatment costs [1]. Since the mid-90s of the last century, thanks to the development of new surgical techniques and implants, as well as antibiotic prophylaxis [2] and due to the possibility of detailed instrumental studies, active surgical treatment in patients with limb fractures needs long-term rehabilitation. Several protocols for early rehabilitation with kinesitherapy exist [3-5], but the resulting postoperative complications [6] compromise flawless surgical performance. One major issue with physiotherapy is that many physical treatments are unsuitable for patients with metal implants due to contraindications [7]. Recently, new and advanced methods have been developed as an alternative approach. These methods are widely used to reduce fibrosis, joint contractures, and swelling and to prevent potential wound complications [8]. In the past decade, the frequency of knee arthroplasty has increased. The most notable advancement has been the introduction of navigation systems for knee arthroplasty [9]. This technology has shown the potential to significantly improve surgeon accuracy and reduce adverse outcomes, promising a bright future for orthopedic surgery.

The study investigates the potential benefits of physical therapy techniques for patients who have received Navigated total knee replacement. The aim of the present study is to analyze the outcomes after total knee replacement in patients with knee arthritis after degenerative changes or fractures around the knee joint. The effectiveness of the treatment is compared at three different points in time by monitoring patient improvement using different measurements.

MATERIALS AND METHODS

The study included ten patients of both sexes aged 42 to 80 years with navigated assisted total knee arthroplasty (OrthoPilot Elite 6.0, AESCULAP) who met the preset inclusion criteria (Figure 1).

Fig. 1. X-ray of a Navigated total knee arthroplasty – preoperative a-p and lateral view and postoperative a-p and lateral view.



The patients were evaluated pre- and postoperatively for a range of motion (contracture) and joint effusion/ edema of the affected lower extremity. The patients underwent assessment at three distinct time points during their stay at the facility. The first assessment (T0) occurred at baseline, before any operative treatment. The second assessment (T1) occurred postoperatively, before the therapeutic course of early rehabilitation. The final assessment (T2) after the seven-day therapeutic course of rehabilitation.

Methods for tracking signs are:

• Knee Injury and Osteoarthritis Outcome Score questionnaire [10];

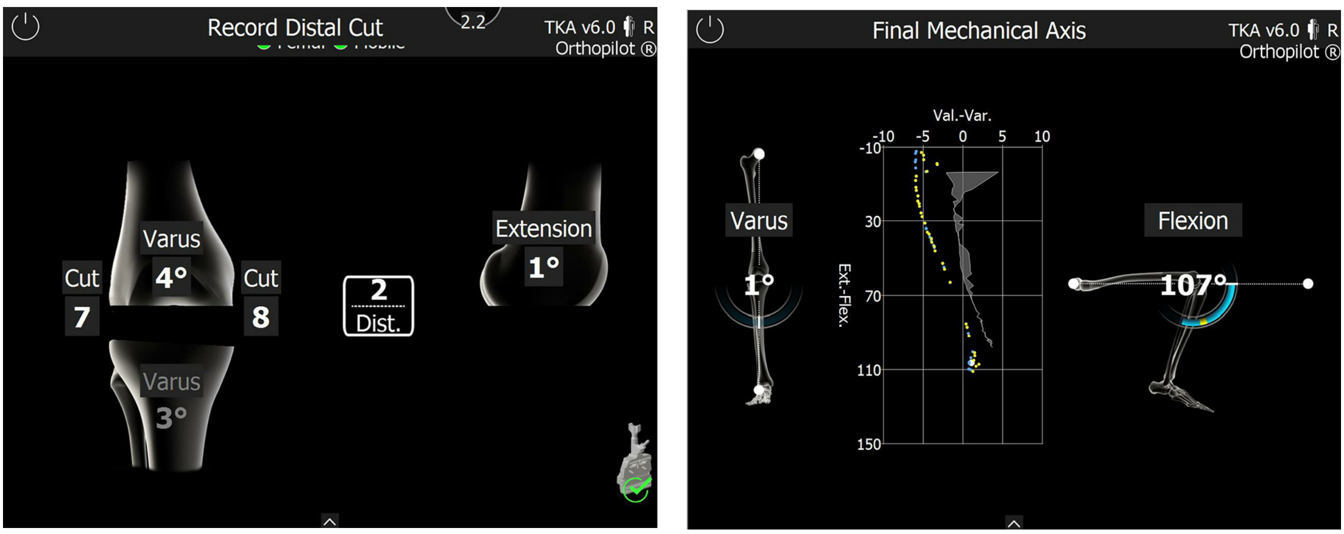
The Knee Injury and Osteoarthritis Outcome Score, or KOOS, assesses five significant outcomes. The modified KOOS consists of four dimensions: pain (nine items), symptoms (seven items), ADL function (17 items), and quality of life (four items). Scores between 0 and 100 represent the percentage of the total possible score achieved.

• Girth measurements
• Range of motion /ROM/
• Pain rating scale - visual analog scale /VAS/[11]

Every patient undergoes a complex treatment involving kinesitherapy and deep oscillation therapy in a seven-day course. Post-surgical rehabilitation for up to one month at the Clinic for Physical and Rehabilitation Medicine / Department of Rehabilitation of the UMBAL "St. Marina" -Varna.

During surgical procedures, navigation systems use the patient's anatomical landmarks to transfer information about alignment in different planes and surgical instruments to a computer. The software then processes this information into visual, graphical, and numerical data that helps surgeons perform each surgical step with greater control and precision. In arthroplasty, the navigation system provides crucial information to the surgeon about the orientation of the cutting guide (varus/valgus, antecurvatum/ recurvatum) (Figure 2).

Fig. 2. The visual, graphical and digital patient data that the Navigated total knee replacement system uses.



These systems assist surgeons throughout the operation, providing crucial data that can inform decision-making and adjustments to the surgical plan. Ultimately, navigation systems help ensure greater precision and safety during surgical procedures [12-13].

The kinesitherapy complex is prepared individually, depending on the established deficit in the range of motion of the knee joint and the observed load requirements in different recovery periods. [14].

Deep Oscillation Therapy is a therapeutic modality that uses an intermittent electrostatic field to provide deep oscillations in the treated area. This method of treatment is used without contraindication for metal implants. Correctly selected exposure parameters help restore elasticity and improve the functional state of tissues, improving local hemodynamics and microcirculation. Therapeutic courses with deep oscillations are performed using an apparatus by the German company Physiomed. The selected program is suitable for therapy in the presence of metal osteosynthesis. The selected frequencies are 160 Hz- 8 min. and 60 Hz- 10 min [15 -18].

The statistical methods used included the Kolmogorov-Smirnov test for normal distribution and the Shapiro-Wilk test for samples with less than 100 data points. The one-way repeated measures ANOVA test expands the paired-sample t-test. This study aimed to test whether the average values for knee circumference, flexion, VAS, symptoms, DEH, and quality of life (QOL) for T0, T1, and T2 are equivalent. Pairwise comparisons were conducted using the Bonferroni method. In addition, the Friedman test, a nonparametric alternative to one-way analysis of variance, was used to evaluate a range of motion and discomfort. This test does not require the data to follow a specific distribution.

RESULTS

Knee circumference result:

A statistically significant effect of time has been detected: Wilks' Lambda=0.361, F=7.069, p=0.017. Pairwise comparison showed that there was a statistically significant difference between T2 and T3 but no statistically significant difference between T1 and T3 and between T1 and T2 (Table 1).

Table 1. Effect time. Circumference

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,64	7,069[a]	2,0	8,0	0,017	0,63
Wilks' Lambda	0,36	7,069[a]	2,0	8,0	0,017	0,63
Hotelling's Trace	1,77	7,069[a]	2,0	8,0	0,017	0,63
Roy's Largest Root	1,77	7,069[a]	2,0	8,0	0,017	0,63

Result flexion:

A statistically significant effect of time was found: Wilks' Lambda = 0.213, F = 14.816, p = 0.002. A pairwise comparison revealed a statistically significant difference between T1 and T3. However, there was no statistically significant difference between T1 and T2 and between T3 and T2 (Table 2).

Table 2. Effect time. Flexion

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,78	14,816[a]	2,0	8,0	0,002	0,78
Wilks' Lambda	0,21	14,816[a]	2,0	8,0	0,002	0,78
Hotelling's Trace	3,7	14,816[a]	2,0	8,0	0,002	0,78
Roy's Largest Root	3,7	14,816[a]	2,0	8,0	0,002	0,78

Result VAS:

A statistically significant effect of time was found: Wilks' Lambda=0.149, F=22.884, p<0.001. Pairwise comparisons revealed a statistically significant difference between T1 and T3 but no statistically significant difference between T1 and T2 or between T3 and T2 (Table 3).

Table 3. Effect time. VAS

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,85	22,884[a]	2,0	8,0	0	0,85
Wilks' Lambda	0,14	22,884[a]	2,0	8,0	0	0,85
Hotelling's Trace	5,7	22,884[a]	2,0	8,0	0	0,85
Roy's Largest Root	5,7	22,884[a]	2,0	8,0	0	0,85

Result symptoms:

A statistically significant effect of time was found: Wilks' Lambda=0.105, F=34.031, p<0.001. Pairwise comparison showed that there was a statistically significant difference between T1 and T3, between T1 and T2, and between T3 and T2 (Table 4).

Table 4. Effect time. Symptoms

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,89	34,03[a]	2,0	8,0	0	0,89
Wilks' Lambda	0,1	34,03[a]	2,0	8,0	0	0,89
Hotelling's Trace	8,5	34,03[a]	2,0	8,0	0	0,89
Roy's Largest Root	8,5	34,03[a]	2,0	8,0	0	0,89

Result: activities of daily living

The analysis found a statistically significant effect of time on activities of daily living: Wilks' Lambda =0.066, F=56.419, p<0.001. Pairwise comparison revealed a significant difference between T1 and T2 but no significant difference between T1 and T3 or between T3 and T2 (Table 5).

Table 5. Effect time. Activities of daily living

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,93	56,41[a]	2,0	8,0	0	0,93
Wilks' Lambda	0,06	56,41[a]	2,0	8,0	0	0,93
Hotelling's Trace	14,1	56,41[a]	2,0	8,0	0	0,93
Roy's Largest Root	14,1	56,41[a]	2,0	8,0	0	0,93

Result: quality of life

A statistically significant effect of time was found: Wilks' Lambda=0.139, F=24,793, p<0,001. A pairwise comparison showed that there was a statistically significant difference between T1 and T2, but there was no statistically significant difference between T1 and T3 and between T3 and T2 (Table 6).

Table 6. Effect time. Quality of life

	Value	F	Hypothesis df	error df	sig	partial eta squared
Pillai's Trace	0,86	24,79[a]	2,0	8,0	0	0,86
Wilks' Lambda	0,139	24,79[a]	2,0	8,0	0	0,86
Hotelling's Trace	6,19	24,79[a]	2,0	8,0	0	0,86
Roy's Largest Root	6,19	24,79[a]	2,0	8,0	0	0,86

Result: extension and pain

The data collected for knee extension and pain during movement showed that the samples did not follow a normal distribution. The Friedman test was used to analyse the data as a nonparametric alternative to one-way analysis of variance for related samples. This test does not rely on the data being normally distributed.

A statistically significant difference exists in the extension frequency distributions for the three time points, c2=7.818, p=0.002 (Table 7). In the presence of a statistically significant test for the overall difference between the three-time points for pairwise comparisons, post hoc Wilcoxon tests with the Bonferroni corrected p-value was performed. α=0.05, the Bonferroni corrected value equals 0.05/3=0.0167, or only at p≤0.0167 will the Wilcoxon test be considered significant. The pairwise comparison shows no difference (p>0.0167) (Table 8).

Table 7. Friedman Test. Extension

N	10
Chi-Square	7,818
df	2
Asymp. Sig.	0,02

Table 8. Extension

	T2-T1	T0-T2	T1-T0
Asymp. Sig. (2-tailed)	0,02	0,06	0,9

A statistically significant difference exists in the pain frequency distributions for the three time points, c2=12,66, p=0.02 (Table 9).

A pairwise comparison showed that there was a difference in pain between time T0 and T1 (p=0.005) and no difference between time T1 and T2 and between T0 and T2 (Table 10).

Table 9. Friedman Test. Pain

N	10
Chi-Square	12,66
df	2
Asymp. Sig.	0,002

Table 10. Pain

	T2-T1	T0-T2	T1-T0
Asymp. Sig. (2-tailed)	0,55	0,037	0,005

DISCUSSION:

In recent years, many different types of knee prostheses have become available on the market, but the functional results after total knee arthroplasty are not optimal. Nevertheless, navigation usage was the most significant advance in instrumentation for total knee arthroplasty over the last decade. It allows a precision tool for carrying out surgery, with the possibility of intraoperative simulation and control of bone resections and better alignment, ligament balance and verification of component rotation. This leads to symmetrical flexion and extension gaps and allows for an individualized approach for every patient.

Some drawbacks of using navigation during surgery include additional intraoperative time for marker placement, technical issues and a steep learning curve. Additionally, using navigation can lead to added costs and increased expenses.

Navigation ensures postoperative protocol with detailed information about preoperative deformation regarding lower limb axis and degrees of motion, different cuts in mm, tension balancing, and postoperative information about alignment and motion. Early active physiotherapy/ deep oscillation, in combination with the advantages of navigated total knee replacement (less blood loss, less swelling, protection of soft tissues – muscles, tendons, etc.), leads to better functional results in the early postoperative phase.

CONCLUSION/S/:

Although navigation for knee arthroplasty is still limited, it has been increasing. These systems give the surgeon in-depth knowledge and allow for a more natural perception of the complex knee kinematics.

Physical therapy can significantly impact the treatment of symptoms in patients with navigated knee replacement. The use of computer navigation in total knee arthroplasty has several advantages. Deep Oscillation therapy has the potential to significantly impact the treatment of symptoms in patients with orthopedic implants. This could lead to a shorter period of forced rest and help prevent complications from operative treatment, offering a promising future for patient care. Early active physiotherapy/ deep oscillation, which involves [specific details about the therapy], in combination with the benefits of navigated total knee replacement (reduced blood loss, less swelling, spared soft tissue – muscles, tendons, etc.) results in better functional outcomes in the early postoperative period.

The results underscore the necessity for further, long-term, and comparative research, which would establish the statistically significant superiority of the complex therapy we have applied. This ongoing research is crucial for the continued advancement of orthopedic treatment.

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