Literature review

THE IMPACT OF COMPUTER-ASSISTED NAVIGATED TOTAL KNEE ARTHROPLASTY ON OPERATIVE TIME

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Background: The knee joint, due to its anatomy, biomechanics, and function, represents a highly complex mechanical system. In recent years, the implantation of artificial knee joints has increased significantly worldwide as a means of reducing pain and improving mobility. Although total knee arthroplasty is currently the most commonly used treatment for advanced-stage gonarthrosis, the high effectiveness of surgical treatment, functional restoration of mobility, and predictability of outcomes remain ongoing challenges.

Objectives: The aim of this study was to identify the advantages of computer-assisted surgical navigation in the treatment of gonarthrosis and to evaluate its impact on operative time.

Methods: A total of 100 patients who underwent primary total knee arthroplasty between 2020 and 2024 were included in the study (cruciate-retaining, mobile-bearing implants). All procedures were performed using a tibially fixed polyethylene insert with preservation of the posterior cruciate ligament (Aesculap). Patients were divided into two main groups: the N-group, who underwent computer-assisted navigated total knee arthroplasty with patellar resurfacing (OrthoPilot®, B. Braun Aesculap), and the S-group, who underwent total knee arthroplasty with patellar resurfacing using the standard conventional technique. The total operative time for both standard and navigation-assisted procedures was recorded and documented for statistical analysis, measured from skin incision to wound closure.

Results: No statistically significant differences were observed between the groups with respect to age or sex. In patients who underwent computer-assisted surgery, the mean operative time (M = 68.50; SD = 8.29 minutes) was significantly shorter compared with patients treated using the standard technique (M = 80.58; SD = 10.47 minutes).

Conclusions: On average, the navigation-assisted group required approximately 12 minutes less operative time than the group treated with the standard methodology.

Key words: Gonarthrosis; Navigation in knee endoprosthesis implantation; OrthoPilot; Total knee arthroplasty.

INTRODUCTION:

It should be noted that in patients over 60 years of age, approximately 90% of cases of gonarthrosis ultimately result in total knee arthroplasty. Consequently, this condition represents not only a medical but also a significant social problem. Although total knee arthroplasty is currently the most widely used treatment for advanced-stage gonarthrosis, the high effectiveness of surgical treatment, full functional restoration of mobility, and reliable predictability of outcomes remain relevant challenges.

Despite the availability of modern, well-established techniques and high-quality implants produced by leading medical technology companies worldwide, consistently high clinical outcomes are not always achieved. This is reflected in the relatively high incidence of postoperative complications, including early implant loosening, dislocation, persistent pain, severe limitation of mobility, prolonged rehabilitation, and infectious or other inflammatory processes associated with implant instability. Many authors associate early loosening of knee endoprostheses primarily with infection. Since prolonged operative time increases the risk of both infectious and other postoperative complications, optimizing surgical duration is crucial.

The concept of computer-assisted navigation systems was developed in response to the problems associated with knee arthroplasty described in the international medical and scientific literature. This approach is based on establishing a relationship between highly accurate, anatomically precise implant positioning and the quality of postoperative biomechanical joint restoration, which ultimately has a significant impact on implant longevity. Navigation systems such as OrthoPilot allow not only the precise determination of bone resection planes tailored to the individual patient but also the assessment of ligamentous tension and the selection of the appropriate implant size [5,6,22].

Why is it so important for a knee endoprosthesis to closely match the patient's individual anatomy? The knee joint is a complex structure with unique, patient-specific biomechanics. Applying a standardized anatomical approach to all patients and performing arthroplasty accordingly neglects individual anatomical variability. This may alter the joint's natural range of motion and affect surrounding structures, including patellar positioning, ligament tension, and overall joint stability. This also explains why up to 20% of patients report dissatisfaction after conventional total knee arthroplasty [2,3].

Since navigation-assisted knee arthroplasty is a relatively recent technique and requires additional specialized training, its widespread implementation on a global scale has not yet been achieved [4]. As a result, studies evaluating outcomes of computer-assisted knee arthroplasty and related scientific publications remain limited. Most available publications in the international literature focus primarily on postoperative radiological outcomes of navigated knee arthroplasty [7]. However, equally important are analyses of clinical outcomes, operative and rehabilitation time, postoperative biomechanical characteristics of the knee joint, and pain intensity.

Among the reported disadvantages, J.M. Strauss and W. Rüther emphasized that navigation-assisted procedures are more time-consuming, increasing operative time by an average of 19 minutes. Nevertheless, recent advances in surgical techniques and improved familiarity with navigation system functionality have significantly optimized the procedure.

The aim of the present study is to demonstrate, using statistical analysis, that under modern conditions an experienced surgical team requires the same, or even less, operative time when performing navigation-assisted total knee arthroplasty as with the standard conventional technique.

METHODS

The study included patients who underwent primary total knee arthroplasty between 2020 and 2024 using mobile-bearing implants with patellar resurfacing. All procedures were performed using a tibially fixed polyethylene insert with preservation of the posterior cruciate ligament (Aesculap). Patients with stage III–IV gonarthrosis according to the Kellgren–Lawrence classification were selected for the study.

Patients were divided into two main groups:

N group: patients who underwent computer-assisted navigation total knee arthroplasty with patellar resurfacing (OrthoPilot®, B. Braun Aesculap).

S group: patients who underwent total knee arthroplasty with patellar resurfacing using the standard conventional technique.

Age groups were defined as follows:

Group I: 50–65 years

Group II: 66–80 years

Gender distribution was categorized as male (M) and female (F).

The study included 100 patients (50 females and 50 males) who underwent primary total knee arthroplasty with patellar resurfacing between 2020 and 2024. Of these, 50 patients were assigned to the N group (25 females, 25 males) and 50 patients to the S group (25 females, 25 males).

RESULTS:

No statistically significant differences in outcomes were observed by age or sex. Overall, among the 100 patients, the mean operative time was approximately 74 minutes (M = 74.54; SD = 11.18) (Table 1).

DISCUSSION

It should be noted that in patients who underwent surgery with computer-assisted navigation, the mean operative time (M = 68.50; SD = 8.29) was significantly shorter than in patients who underwent surgery with the standard conventional technique (M = 80.58; SD = 10.47) (Table 2).

CONCLUSIONS:

In the computer-assisted surgery group, the mean operative time was reduced by approximately 12 minutes compared with the standard technique group. This difference was statistically significant ($t(98) = 6.39$; $p < .05$). In addition, it is noteworthy that the standard deviation of the mean operative time was lower in the computer-assisted group than in the standard surgery group, indicating that operative duration in navigation-assisted procedures was more consistent and homogeneous.

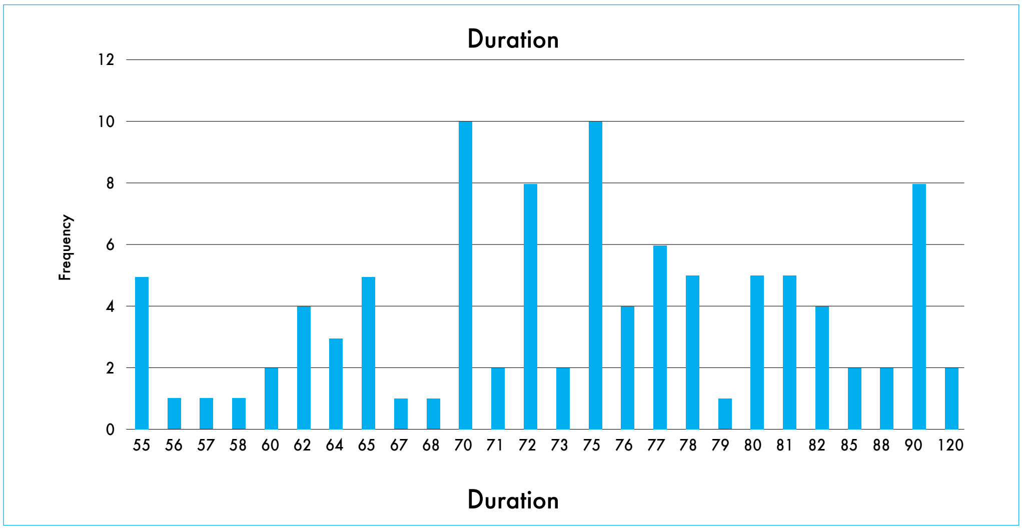

Chart 1. Duration - 1

Table 1. Operation time

PATIENT	OPERATION TIME 50 Patients who underwent Computer-assisted TKA with patellar resurfacing using a navigation system	OPERATION TIME 50 Patients who underwent Standard (non-navigated) TKA with patellar resurfacing
NR.1	72 MIN	90 MIN
NR.2	77 MIN	82 MIN
NR.3	55 MIN	85 MIN
NR.4	90 MIN	120 MIN
NR.5	62 MIN	85 MIN
NR.6	70 MIN	70 MIN
NR.7	76 MIN	78 MIN
NR.8	64 MIN	90 MIN
NR.9	55 MIN	72 MIN
NR.10	76 MIN	82 MIN
NR.11	65 MIN	88 MIN
NR.12	73 MIN	90 MIN
NR.13	80 MIN	81 MIN
NR.14	75 MIN	70 MIN
NR.15	78 MIN	90 MIN
NR.16	72 MIN	90 MIN
NR.17	65 MIN	72 MIN
NR.18	75 MIN	81 MIN
NR.19	55 MIN	72 MIN
NR.20	56 MIN	80 MIN
NR.21	68 MIN	82 MIN
NR.22	76 MIN	78 MIN
NR.23	64 MIN	72 MIN
NR.24	75 MIN	81 MIN
NR.25	65 MIN	70 MIN
NR.26	60 MIN	90 MIN
NR.27	62 MIN	120 MIN
NR.28	55 MIN	75 MIN
NR.29	78 MIN	70 MIN
NR.30	77 MIN	80 MIN
NR.31	57 MIN	70 MIN
NR.32	58 MIN	75 MIN
NR.33	62 MIN	77 MIN
NR.34	77 MIN	81 MIN
NR.35	62 MIN	77 MIN
NR.36	75 MIN	72 MIN
NR.37	70 MIN	70 MIN
NR.38	76 MIN	75 MIN
NR.39	55 MIN	71 MIN
NR.40	73 MIN	80 MIN
NR.41	75 MIN	81 MIN
NR.42	67 MIN	88 MIN
NR.43	60 MIN	72 MIN
NR.44	65 MIN	82 MIN
NR.45	70 MIN	90 MIN
NR.46	75 MIN	80 MIN
NR.47	65 MIN	78 MIN
NR.48	64 MIN	70 MIN
NR.49	77 MIN	79 MIN
NR.50	71 MIN	75 MIN

Table 2. Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Duration	N	50	68.5000	8.29125	1.17256
	S	50	80.5800	10.47658	1.48161

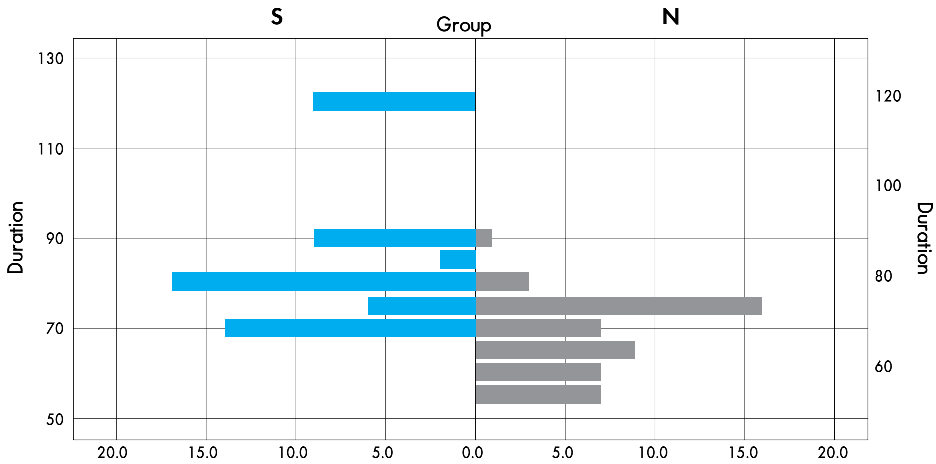

Chart 2. Duration - 2

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მუხლის სახსრის კომპიუტერული ნავიგაციით ენდოპროთეზირების უპირატესობის გავლენა საოპერაციო დროის ფაქტორზე

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რეზიუმე მუხლის სახსარი თავისი ანატომიით, ბიომექანიკით და ფუნქციით წარმოადგენს საკმაოდ რთულ მექანიზმს. ტკივილის შემცირების და მოძრაობის გაუმჯობესების მიზნით, მუხლის ხელოვნური სახსრის იმპლანტაციამ, მსოფლიო მასშტაბით საგრძნობლად იმატა ბოლო წლებში. მიუხედავად იმისა, რომ მაღალი სტადიის გონართროზის მკურნალობის ყველაზე გავრცელებული მეთოდი დღეისთვის არის ტოტალური ენდოპროთეზირება, ოპერაციული მკურნალობის მაღალი შედეგიანობა, გადაადგილების უნარის ფუნქციური სრულყოფა და გამოსავლის შედეგების პროგნოზირება კვლავ რჩება აქტუალურ პრობლემად. თანამედროვე მსოფლიო რეალობაში მოწოდებული და აპრობირებული მეთოდები, წამყვანი სამედიცინო ქვეყნების მიერ წარმოებული უმაღლესი ხარისხის იმპლანტების გამოყენებით, მაინც ვერ იძლევა ყოველთვის მაღალ შედეგს. ბევრი ავტორისთვის ენდოპროთეზის ადრეული მორყევა ძირითადად ინფექციასთან ასოცირდება. ვინაიდან, ოპერაციის ხანგრძლივი მსვლელობა ზრდის, როგორც ინფექციის, ასევე სხვა პოსტოპერაციული პათოლოგიების განვითარების რისკს, ოპერაციის დროის ოპტიმიზაციას მნიშვნელოვანი როლი ეკისრება. კომპიუტერით ასისტირებული სანავიგაციო სისტემის შექმნის იდეა დაკავშირებული იყო მსოფლიო სამედიცინო-სამეცნიერო ლიტერატურაში აღწერილი მუხლის სახსრის ენდოპროთეზირებასთან დაკავშირებული პრობლემების გადაჭრის გზების ძიებასთან. რასაც საფუძვლად ედო კავშირების დადგენა იმპლანტის სახსარში, მაღალი ანატომიური, ბუნებრივი სიზუსტით განთავსებასა და სახსრის პოსტოპერაციულ ბიომექანიკურ ფუნქციის ხარისხიანად აღდგენის პროცესს შორის. რაც საბოლოოდ მნიშვნელოვანწილად განსაზღვრავს ენდოპროთეზის ექსპლუატაციის ვადას. უარყოფითი მხარეებიდან, J.M. Strauss და W.Rüther თავის სტატიაში ხაზს უსვამენ, რომ ნავიგაციით ჩატარებული ოპერაცია უფრო ხანგრძლივია და საშუალოდ 19 წუთით ზრდის დროს. თუმცა, ბოლო პერიოდში ოპერაციული ტექნიკა დაიხვეწა, აგრეთვე კარგად ათვისებული იქნა სანავიგაციო კომპიუტერული აპარატის მუშაობის პრინციპები. კვლევის ამოცანა იყო, სანავიგაციო კომპიუტერული სისტემით, გონართროზის ქირურგიული მკურნალობის უპირატესობების დადგენა და მათი გავლენა საოპერაციო დროსთან მიმართებაში. ჩვენი ნაშრომის მიზანია, სტატისტიკურ მასალაზე დაყრდნობით, დაამტკიცოს, რომ თანამედროვე პირობებში, გამოცდილ საოპერაციო გუნდს იგივე ან უფრო ნაკლები დრო სჭირდება ოპერაციის ნავიგაციით მართვისას, ვიდრე სტანდარტული ენდოპროთეზირებისას.

საკვანძო სიტყვები: გონართროზი; მუხლის სახსრის ენდოპროთეზირების ნავიგაცია; ორთოპილოტი; მუხლის სახსრის ტოტალური ენდოპროთეზირება.