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Review Article

Use of the Navigation System in Total Knee Arthroplasty Surgery in The Last 10 Years: Literature Review

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Abstract

Navigation systems utilized in total knee arthroplasty surgeries are sophisticated tools that enhance the precision and accuracy of procedures conducted by orthopedic surgeons who specialize in knee replacements. The primary objective of this study is to conduct a comprehensive literature review with a specific focus on assessing the practicality of employing surgical navigation systems in unilateral knee arthroplasty surgeries, with a particular emphasis on kinematic alignment, within the realm of orthopedics and traumatology. To achieve this, we systematically surveyed reputable databases, including PubMed, ScienceDirect, and Scielo, utilizing a set of predefined keywords: "Total Knee Arthroplasty," "Navigation System," "Primary Prosthesis," "Osteoarthrosis," and "Arc of Motion." The selection criteria we established for the review encompassed articles published between 2013 and 2023, available in both English and Portuguese, and accessible electronically without charge. We accorded priority to experimental and clinical studies as primary sources of information, concentrating specifically on the elderly demographic diagnosed with unilateral knee osteoarthritis.

Our research aims to thoroughly analyze and synthesize the existing body of scientific evidence, furnishing a robust perspective on the efficacy of employing navigation systems by orthopedic surgeons during unilateral total knee arthroplasty procedures conducted during the stipulated period. This undertaking is anticipated to make a meaningful contribution to the progression of knowledge within the field and, more importantly, to benefit both the medical community and the individuals afflicted by this condition.

Keywords: Total Knee Arthroplasty; Navigation System; Kinematic Alignment; Orthopedics

Introduction

Navigation-assisted surgery for Knee prosthesis implantation (KTA) is an advanced procedure that uses computer navigation systems to assist orthopedic surgeons in obtaining precise alignment during the prosthesis insertion process. This system performs a thorough record of the patient's knee anatomical structures, generating a three-dimensional (3D) virtual model of the knee. This information is essential to allow the surgeon to perform bone cuts with exact angles and depths, thus ensuring the precise placement of the prosthesis. Recent research has corroborated the effectiveness of this approach [1-3].

These navigation systems use tracking and imaging technology to provide real-time information during the surgical procedure, giving the surgeon the ability to make decisions based on precise data and execute cuts and component implants with remarkable precision [1-3]. This system employs sensors and cameras to track the position and movement of the knee joint and surgical tools in real time, providing the surgeon with accurate control over location and orientation during surgery. Throughout the surgical

intervention, the system provides real-time feedback on the position and alignment of the surgical tools and implants in relation to a reference plane. This feature allows the surgeon to adjust as necessary to ensure the desired alignment. Surgical navigation is thus effective in minimizing potential errors, such as misalignment of implants, resulting in a smoother postoperative recovery and optimization of knee function. Therefore, this system can be customized according to the individual anatomical characteristics of each patient, considering their unique anatomy and knee pathology [4,5].

Therefore, the purpose of this study is to investigate the applicability of existing evidence regarding the use of navigation systems during primary total knee arthroplasty surgeries in elderly. To achieve this goal, we conducted a literature review with the aim of consolidating the available evidence on the use of navigation systems during KTA surgery. This study aims to deepen the discussion on the application of this surgical system in the field of orthopedics and traumatology, highlighting the importance of a solid scientific basis in clinical decision-making.

Methods

This is a literature review study, developed with the aim of gathering and synthesizing results from studies carried out using different methodologies, to contribute to the deepening of knowledge related to the use of the navigation system in primary total knee arthroplasty surgeries.

Study description

The study was conducted using the databases: PubMed, ScienceDirect and Scielo from 2013 to 2023. The review process took place in six stages, which will be detailed below:

a) First Phase: elaboration of the guiding question. At this stage, the following question was defined, which the investigation aimed to answer: "How important is it to use a navigation system as an auxiliary resource for the orthopedist during unilateral total knee arthroplasty surgery?" And, through this, it was determined which studies were included, the means adopted for identification and the information collected from each selected study.

b) Second Phase: literature search (in this phase the search in databases established according to the guiding question, considering the model of prosthesis used, brand chosen and the variables of interest).

c) Third Phase: data collection (in this phase data were extracted from the selected articles).

d) Fourth Phase: critical analysis of the studies (in this phase the research data and characteristics of each study selected in the previous phase are presented).

e) Fifth Phase: discussion of the results (in this stage, the data evidenced in the analysis of the articles was compared, possible knowledge gaps were identified, and it was possible to define priorities for future studies).

f) Sixth phase: presentation of the review (results presentation phase). To base the knowledge of orthopedics and traumatology on the use of the navigation system during primary total knee arthroplasty surgeries.

The descriptors "Total Knee Arthroplasty," "Navigated System", "Primary Prosthesis", "Osteoarthrosis", "Arc of Motion" were used. The search and selection of studies took place from December 2022 to July 2023, through online access, where the following inclusion criteria used: complete and available articles that answered the guiding question, written in English and Portuguese, available in the free online database published since 2013. Initially, the articles were analyzed and selected by reading the title and summary of the publications, with studies that specifically addressed the theme of the guiding question being considered eligible. After this evaluation, the selected articles were read in full. A data collection instrument was developed to analyze and synthesize the selected articles. This instrument has information about the author, year, type of system, prosthesis model, analyzed variables and conclusion.

Inclusion and Exclusion Criteria

The inclusion criteria used to carry out the research were: articles that answered the research's guiding question, which were included in the period 2013-2023, that were available free of charge, electronically, complete, in full and that were in English and Portuguese. The exclusion criteria used were that, although scientific research was found using the keywords requested after the interpretative reading, they did not show a correlation with the descriptors described above.

Data Analysis

In the search for studies with crossing the descriptors, a total of 100 articles were found. After publishing the filters: full text available, English, and Portuguese language and database PubMed, ScienceDirect, Scielo, a total of articles remained. According to the available abstracts, based on the inclusion criteria, which was to answer the guiding question, only 38 articles were included, therefore the final sample was composed of 12 articles. Data from each publication were extracted and entered a Mendeley reference management system and tabulated in Microsoft Excel (2023), as shown in Figure 1.

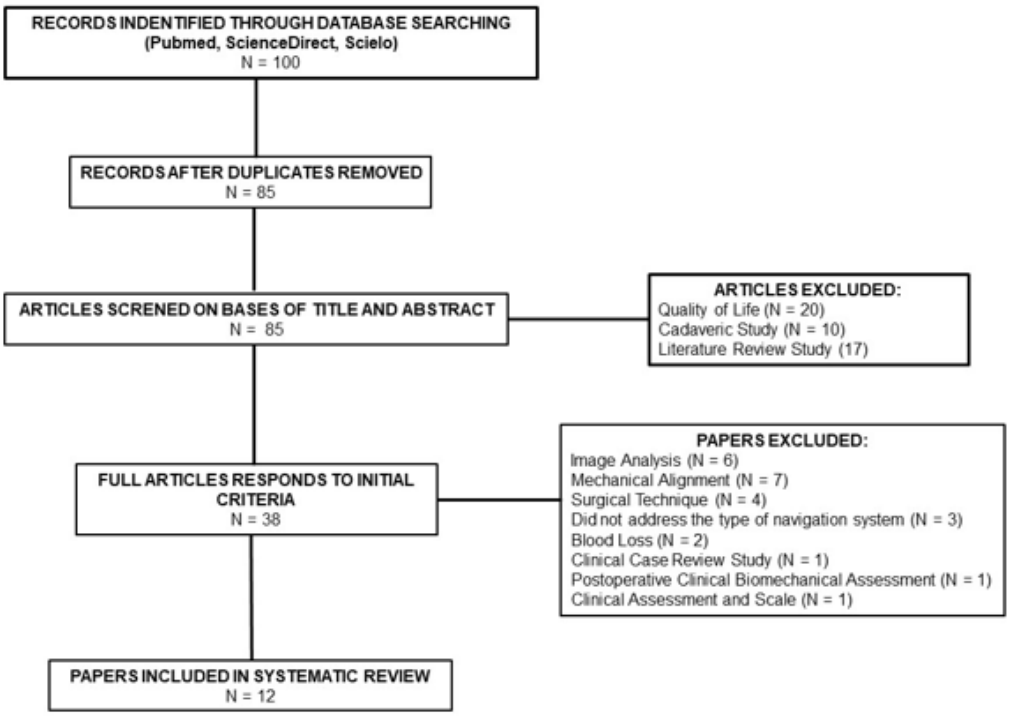

Figure 1: PRISMA diagram for obtaining the literature date base ScienceDirect, Scielo and PubMed.

Ethical aspects

Ethical aspects regarding the reliability of the data and authors found in the articles that are part of the analyzed sample were respected.

Results and Discussion

In the search for studies with crossing descriptors, a total of 100 articles were initially identified. Subsequently, after applying specific filters, such as the availability of the full text, the English language, and the selection of the PubMed, ScienceDirect and Scielo databases, 86 articles remained for further analysis. Among these, only 38 articles met the established inclusion criteria, resulting in a final sample consisting of 12 articles. From this set, it was observed that 68% of the articles published in the databases, focusing on the topic of total knee arthroplasty using navigation, focused on the analysis of the surgical result. Aspects covered included image analysis, mechanical alignment, and blood loss as main points of investigation. However, it is important to highlight that, although many of these articles explored the surgical technique in detail, a significant portion did not present compelling results from this specific technique.

The data from this research were subdivided into two distinct categories. In the first category, the overview of published studies was outlined, highlighting the year of publication and the country where each investigation was conducted. This approach allowed for a comprehensive analysis, both temporal and geographical, of studies related to the topic in question. In the second category, the evaluation was directed to specific aspects of the studied population. This analysis included details such as the primary knee prosthesis model used, the navigation system adopted, as well as checking the range of motion at 0 degrees, 30 degrees, 60 degrees, 90 degrees and 120 degrees.

Geographic Analysis of the Studies

Table 1: Geographic Overview of Selected Studies.

Authors	Year	Country	Data Base
Rober Wer-Wei Hsu, et al.	2019	Taiwan	PubMed
Frank Lampe, et al.	2016	Germany	PubMed
Ogg Jin Shon, et al.	2022	Korea	PubMed
Sergio Mainine, et al.	2021	Brazil	Scielo
Vikran Kandhani, et al.	2022	Austrália	Scielo
Malheiros Luzo, et al.	2014	Brazil	Scielo

Chong Meng Lee, et al.	2018	Malasya	ScienceDirect
Akihiko Toda, et al.	2016	Japan	ScienceDirect
Sung-Yen Lin, et al.	2014	Taiwan	ScienceDirect
F. Châtain, et al.	2013	France	ScienceDirect
A. Desseauxa, et al.	2016	France	ScienceDirect
Kaushik Hazratwala, et al.	2016	Austrália	ScienceDirect

Table 1 offers an informative summary that includes the authors, year of publication and countries in which the selected studies were conducted. These elements provide an essential panoramic view for understanding the temporal and geographic distribution of the works analyzed, establishing an initial basis for a more in-depth assessment of research on the topic in question (Table 1).

Analysis of the PubMed, Scielo and ScienceDirect databases reveals extensive literature available on the use of navigation systems in primary total knee arthroplasty surgeries. This approach allows for a global overview of research conducted over the last 10 years, covering different regions of the world. The literature review in question incorporated 5 studies from Asia [6-9], 3 studies from Europe [10,11], 2 studies from South America [12,13] and 2 studies from Oceania [14,15]. A notable aspect is the greater representation of clinical studies from the Asian continent that met the inclusion criteria established for this review.

Prosthesis Model and Navigation System

Table 2 presents information regarding the model of prosthesis used, model of the navigation system and finally, the assessment of the range of movement was carried out. This dataset seeks to provide a comprehensive overview of the different approaches adopted in recent studies, enriching the global understanding of the use of these innovative technologies in primary total knee arthroplasty procedures (Table 2).

Table 2: The range of motion was considered based on the analysis of femoral and tibial movement at 0 degrees, 30 degrees, 60 degrees, 90 degrees and 120 degrees.

Authors	Navigation System	Knee Prosthesis	Motion
Sergio Mainine, et al. (2021)	Amplivision (Amplitude Surgical, Valence, France)	SCORE® (Amplitude Surgical, Valence, France)	NR
Vikram Kandhani, et al. (2022)	Ortho Map (Stryker, Kalamazoo, Michigan, U.S.)	NI	3 degrees and 124 degrees (Valgus, Varus and Flexion)
Malheiros Luzo, et al (2014)	Ortho pilot® (B. Braun, Melsungen, Alemanha)	Columbus® Knee prosthesis (B. Braun, Melsungen, Alemanha)	Mechanical Axis and Flexion and Extension Gap
Rober Wer-Wei Hsu, et al. (2019)	Navitrack-OS Knee system (Zimmer, Warsaw, Indiana, EUA)	Natural Knee II (Zimmer, Warsaw, Indiana, EUA)	NR
Frank Lampe, et al. (2016)	Ortho pilot® (B. Braun, Melsungen, Alemanha)	NI	NR
Chong Meng Lee, et al. (2018)	Ortho Map (Stryker, Kalamazoo, Michigan, U.S.)	Scorpio NRG (Stryker, Kalamazoo, Michigan, U.S.)	NR
Akihiko Toda, et al. (2016)	NAV3i (Stryker, Kalamazoo, Michigan, U.S.)	Triathlon® PKR (Stryker, Kalamazoo, Michigan, U.S.) Unicompartmental High Flex Knee (Zimmer, Warsaw, Indiana, EUA)	NR
Sung-Yen Lin, et al. (2014)	Vision knee NA system (BrainLAB, Munich, Germany).	Legacy Knee Posterior Stabilized (LPS) (Zimmer, Warsaw, Indiana, EUA)	0 and 120 degrees and functional score
F. Châtain, et al. (2013)	Amplivision (Amplitude Surgical, Valence, France)	SCORE® (Amplitude Surgical, Valence, France)	NR

A. Desseauxa, et al. (2016)	ORTHO Soft (Zimmer, Warsaw, Indiana, EUA)	NI	NR
Kaushik Hazratwala, et al. (2016)	Ortho Map (Stryker, Kalamazoo, Michigan, U.S.)	NI	NR
Oog Jin Shon, et al. (2022)	ExactechGPS (Gainesville, Florida, USA)	Truliant Primary Knee (Gainesville, Florida, USA)	NR
NR – Indicates not Evaluated. NI – Indicates not informed.			

The integration of navigation systems in primary total knee arthroplasty surgeries represents a revolution in the orthopedic surgical approach, providing significant advances in precision and results. In this analysis, we highlight studies that explore the diversity of navigation systems and their applications (1-3). Sergio Mainine, et al. used the Amplivision system (Amplitude Surgical, Valence, France) in conjunction with the SCORE® prosthesis (Amplitude Surgical, Valence, France), although without providing details about the analysis of the range of motion. In contrast, Vikram Kandhani, et al. (2022) used the OrthoMap system (Stryker, Kalamazoo, Michigan, USA) without specifying the prosthesis used. Malheiros Luzo, et al. (2014) opted for the Orthopilot® system (B. Braun, Melsungen, Germany) in combination with the Columbus® Knee prosthesis (B. Braun, Melsungen, Germany), focusing on the assessment of the mechanical axis and the flexion and extension gap. Rober Wer-Wei Hsu, et al. (2019) chose the Navitrack-OS Knee system (Zimmer, Warsaw, Indiana, USA) in conjunction with the Natural Knee II prosthesis (Zimmer, Warsaw, Indiana, USA), but did not address the analysis of arc of movement.

Frank Lampe, et al. (2016) used the Orthopilot® system (B. Braun, Melsungen, Germany) without informing the prosthesis and without analyzing the range of motion. On the other hand, Chong Meng Lee, et al. (2018), Akihiko Toda, et al. (2016), F. Châtain, et al. (2013), A. Desseauxa, et al. (2016) and Kaushik Hazratwala, et al. (2016) do not included the assessment of range of motion in their respective research. Sung-Yen Lin, et al. (2014) used the Vision knee NA system (BrainLAB, Munich, Germany) with the Legacy Knee Posterior Stabilized (LPS) prosthesis (Zimmer, Warsaw, Indiana, USA), evaluating the range of motion between 0 and 120 degrees, in addition to conducting a functional analysis. Finally, Oog Jin Shon, et al. (2022) used the ExactechGPS system (Gainesville, Florida, USA) with the Truliant Primary Knee prosthesis (Gainesville, Florida, USA), although they did not perform a specific assessment of the range of motion.

The advancement of navigation system in Total Knee Arthroplasty (TKA) surgeries incorporates advanced technologies such as optical tracking, real-time monitoring, and computer-assisted surgical planning software. These innovations have provided surgeons with more detailed insight and more precise guidance when performing TKAs. Despite the numerous benefits offered by these technologies, the studies analyzed in this literature review reveal a significant gap. The researchers focused on evaluating cuts (femoral and tibial) and examining elements such as the ligament gap, range of motion, using scales and physical examination. The lack of detailed exploration of these advanced features offered by navigation systems, such as real-time assessment of range of motion and joint stability, highlights an opportunity to improve the surgical approach. Integrating these features could not only improve the accuracy of prosthesis placement, but also allow for more refined analysis of the alignment and positioning of implanted components.

Conclusion

The use of navigation systems in primary total knee arthroplasty surgeries represents a notable revolution in the orthopedic surgical approach. Recent studies highlight the diversity of systems used, such as Amplivision, OrthoMap, Orthopilot, Navitrack-OS Knee and ExactechGPS, reflecting the constant technological evolution in this field. However, a notable gap arises in the analysis of the studies, because, although they have emphasized aspects such as cuts (femoral and tibial), ligament gap and range of motion, the complete exploration of the advanced resources provided by navigation systems, such as detailed analysis in time range of motion and joint stability remains limited.

This gap provides a significant opportunity to improve the surgical approach, highlighting the need for a more comprehensive investigation of these advanced features. A more refined analysis of these aspects, fully integrating the technological advances offered by navigation systems, could not only improve the accuracy of prosthesis placement, but also contribute significantly to quality of life and post-surgical recovery. Therefore, considering the potential positive impact of these resources, full implementation of these technologies may represent a crucial next step in optimizing outcomes in primary total knee arthroplasties.

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