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3D Planning in Total Hip Arthroplasty: A New Approach to More Precise Surgery

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Abstract **Original Research Article**

Introduction: The objective of this work was to evaluate clinically and radiographicallythe results of computer-assisted total knee arthroplasty in the management of coxarthrosis, the influence of certain factors on the results compared to conventional arthroplasty, its limits andits complications. ***Methods:*** We conducted a review of the literature concerning the interest of 3D planningin total hip prosthesis. ***Results:*** In terms of functional results, a clear clinical improvement was noted, in particular thanks to the relatively short duration of the operation and especially thanks to the hospitalization time of an average of 5 days. The survival rate of the prostheses was 100%. The radiographic results were also satisfactory with a markedly improved Harris functional score, a very close leg length with an overall inclination angle of 38 compared to 45for the conventional prosthesis. ***Conclusion:*** Our study confirmed the data in the literature concerning the results of computer-assisted total hip arthroplasty, and supported the advantages and disadvantages of this technique.

Keywords: Coxarthrosis - total hip arthroplasty - 3D planning.

INTRODUCTION

1. RESEARCH BACKGROUND AND RATIONALE

Total hip replacement is a common surgical procedure for patients suffering from osteoarthritis of the hip. Intraoperative planning for hip replacement is an important step in the surgical process, as it helps determine the optimal size and location of the prosthesis. 3D planning of the hip prosthesis is a recent method that uses 3D modeling technologies to improve the accuracy and reliability of planning. This method makes it possible to visualize the patient's hip in 3D, simulate different positions and sizes of the prosthesis, and determine the optimum position to minimize the risk of postoperative complications [1, 2].

Although 3D planning of hip prostheses offers many advantages, it is not yet widely used in clinical practice [3].

There may be many reasons for this: lack of information on available techniques and technologies, high costs, lack of surgeon skills and training.

In this context, this research aims to explore the benefits and limitations of 3D planning of hip prostheses, as well as the factors influencing its adoption in clinical practice.

More specifically, this research aims to:

- Describe the basic concepts of 3D planning for hip prostheses,
- Present the techniques and technologies available for 3D planning,
- Compare the results of 3D planning with those of traditional planning
- Identify the factors influencing the adoption of 3D planning in clinical practice, and
- Propose recommendations to improve the adoption of 3D planning for hip prostheses.

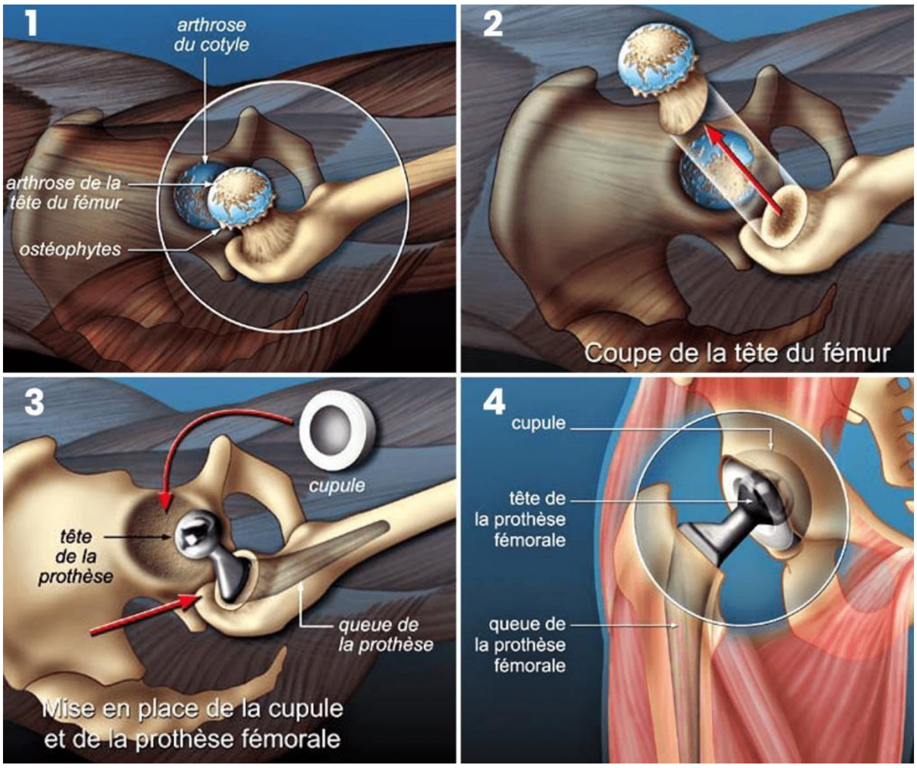

Figure 1: Total hip replacement in osteoarthritis

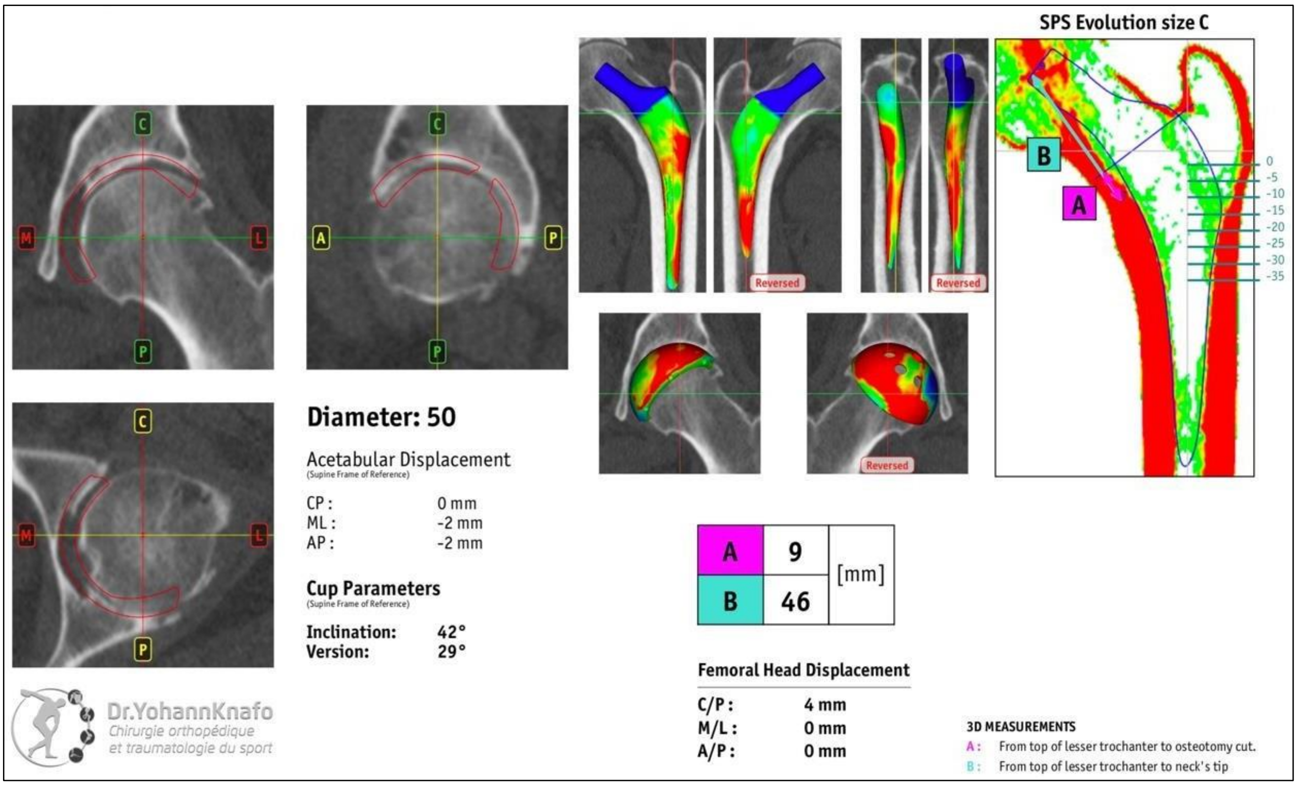

Figure 2: 3D planning for THR surgery

This research is relevant to the medical community, both for patients suffering from osteoarthritis of the hip, and for manufacturers of hip prostheses. It will provide a better understanding of the benefits and limitations of 3D planning of hip prostheses, and propose recommendations to improve its adoption in clinical practice [4, 5].

Indeed, 3D planning of hip prostheses offers a number of advantages over traditional two-dimensional planning based on X-rays. Firstly, it enables a more precise and detailed visualization of the patient's hip, making it easier to determine the optimal size and location of the prosthesis. In addition, 3D planning can simulate different positions and sizes of the prosthesis, enabling selection of the solution best suited to the patient's anatomical characteristics. Finally, it reduces the risk of post-operative complications, particularly with regard to prosthesis position and joint stability.

However, despite these advantages, it is not yet widely used in clinical practice. Several factors may explain this situation, such as the high cost of 3D modeling technologies, the lack of skills and training among surgeons, and the lack of evidence of the efficacy and safety of this method. This research aims to answer these questions by examining the benefits and limitations.

This research aims to fill a gap in current knowledge about 3D planning of hip prostheses by examining the benefits and limitations of this method, as well as the factors influencing its adoption in clinical practice. The results of this research could have a significant impact on the quality of care for patients suffering from osteoarthritis of the hip, as well as on the development of new hip prosthesis technologies better adapted to the real needs of the market [6].

2. RESEARCH PROBLEM AND OBJECTIVES

The real issue in this research is the advantages and limitations of 3D planning of hip prostheses, and the factors influencing its adoption in clinical practice. Despite the potential advantages of this method, it is not yet widely used in clinical practice. Therefore, it is important to understand the reasons for this situation in order to improve the efficiency and safety of care for patients with osteoarthritis of the hip [7].

3. RESEARCH PLAN DESCRIPTION

The research plan is divided into four main stages. Firstly, a literature review will be carried out to understand the basic concepts of 3D planning of hip prostheses, the techniques and technologies used for 3D planning, and the results of existing studies on the subject. Then, a cross-sectional study will be conducted to evaluate the efficacy and safety of 3D planning of hip prostheses in comparison with traditional two-dimensional planning based on radiographs [8].

Next, interviews will be conducted with surgeons and other healthcare professionals involved in the management of patients requiring hip arthroplasty to identify factors influencing the adoption of 3D hip planning. The interviews will be analyzed to identify the main barriers to the adoption of 3D hip planning, and recommendations for improving the adoption of 3D hip planning will be formulated based on the results of the study.

Finally, the results of the study will be discussed in terms of their relevance to research and medical practice, highlighting the study's contributions as well as its limitations within our IBN SINA University Hospital in Rabat. Prospects for future work will also be proposed [9, 10].

MATERIALS AND METHODS

I. DESCRIPTION OF 3D PLANNING AND HIP-PLAN SOFTWARE

1. Data source

In this study, several data sources were used to carry out a literature review on 3D planning of hip prostheses. The main sources included bibliographic databases such as PubMed, Scopus and Web of Science, which were searched using specific keywords related to the research topic. Specialized journals in the fields of orthopedics, orthopedic surgery, computer- aided design and bioengineering were also consulted to gather relevant articles. In addition, proceedings of scientific conferences and symposia as well as reference books were reviewed for further information. Inclusion and exclusion criteria were applied to select relevant articles, and a critical analysis was carried out to assess the quality and relevance of the included studies. This comprehensive search approach yielded a diverse range of scientific and clinical publications, providing a solid basis for the literature review and analysis of results.

2. Article Selection Process

a. Inclusion Criteria

- Age between 18 and 80
- Severe osteoarthritis of the hip requiring surgery
- Failure of medical treatment and physiotherapy
- Ability to understand and complete study questionnaires.
- Informed consent to participate in the study.

b. Non-inclusion criteria:

- History of joint infection
- Systemic autoimmune or inflammatory diseases
- Uncontrolled blood coagulation disorder
- Inability to understand or cooperate with post-operative evaluation and follow-up

3. Clinical assessment

In all the studies cited, clinical examination was carried out using a variety of tools. Firstly, a preoperative assessment was carried out to determine the degree of pain, range of motion and functionality of the patient's hip. This assessment was carried out using a pain assessment questionnaire, a hip movement assessment chart and a quality of life assessment questionnaire.

Then, after the 3D prosthesis had been fitted, a postoperative assessment was carried out to determine the improvement in patients' symptoms. This assessment was carried out using the same tools used during the preoperative evaluation. In addition, a radiological assessment was carried out to verify the correct position of the prosthesis and to determine hip stability.

The results of these evaluations were analyzed to determine the effectiveness of 3D planning in improving patients' symptoms, and to assess the suitability of this method for hip prostheses.

4. 3D planning description:

3D planning is an advanced approach used in the medical field, particularly in orthopedics, for the design and preparation of surgical procedures. In the context of 3D planning for hip prostheses, it is a process that creates a virtual three-dimensional representation of the patient's hip and the planned prosthesis.

It begins with the acquisition of high-resolution medical images, such as computed tomography (CT) or magnetic resonance imaging (MRI), which provide a detailed view of the hip's anatomy. These images are then used to create a 3D digital model of the hip, using specialized image reconstruction and segmentation software.

Once the 3D model of the hip has been created, virtual planning tools are used to simulate and optimize the implantation of the prosthesis. This includes selecting the size and shape of the prosthesis, fine-tuning its position and orientation, and assessing its impact on the surrounding anatomy. Precise measurements of angles, distances and dimensions are taken to ensure optimal placement of the prosthesis, tailored to the specific needs of each patient.

3D planning offers several significant advantages over traditional methods. It gives surgeons a better understanding of the patient's anatomy prior to surgery, facilitating preoperative planning and reducing placement errors and postoperative complications. In addition, it enables more precise customization of the prosthesis to the patient's specific anatomical features, which can lead to better functional results and greater patient satisfaction.

In summary, 3D hip planning is an innovative approach that uses advanced imaging techniques and modeling tools to optimize prosthesis design and implantation. It improves the precision, customization and overall results of hip replacement surgery, paving the way for safer, more effective interventions.

5. Explanation of the HIP-PLAN model

HIP-Plan is Symbios' 3D planning software for preoperative planning of hip prostheses. It enables 3D visualization of the hip bones and potential prostheses, definition of the optimal position and orientation of the prosthesis, and prediction of post-operative results.

The planning process begins by segmenting CT images of the hip to create a 3D model of the bones. The model is then imported into the HIP-Plan software, where the surgeon can manipulate the bones and virtual prostheses to determine the best configuration for the patient. The software provides tools for measuring the angle of inclination, leg length, hip bone spacing and other measurements important for prosthesis planning.

HIP-Plan also uses a library of hip prosthesis models to help the surgeon select the most suitable prosthesis for each patient. The prosthesis model can be adjusted to match the manufacturer's specifications or the patient's needs.

Once planning is complete, the results can be exported as a detailed report for sharing with the patient and members of the surgical team. Reports can include pre- and post-planning images of the hip, screenshots of the 3D model, as well as measurements and annotations to aid communication with the patient and preparation for the surgical procedure.

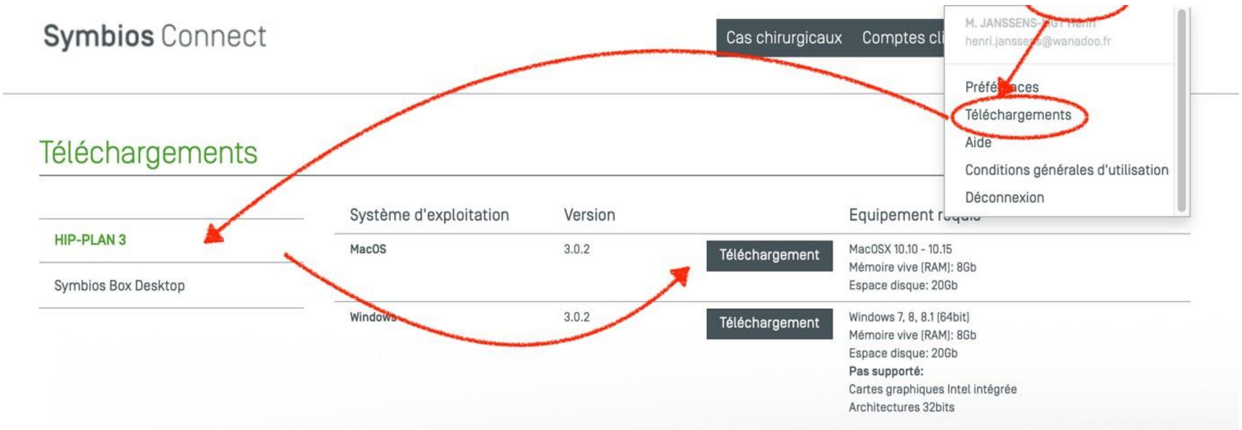

Figure 3: Hip-plan download procedure

RESULTS

I. COMPARISON OF PTH RESULTS UNDER 3D PLANNING AND CONVENTIONAL PTH

The comparative study highlights the differences between patients who underwent 3D planning for hip replacement and patients who underwent normal hip replacement. Clinical and radiological criteria were analyzed to assess the effectiveness of 3D planning.

1. Clinical criteria:

Patients who underwent 3D planning showed a significant reduction in postoperative pain, as well as an improvement in hip function in the first few months after surgery. In addition, the rate of post-operative complications was lower in patients who underwent 3D planning, and there was a considerable intraoperative improvement in mean operating time, with significantly less blood loss than with conventional prostheses.

2. Radiological criteria

Patients who underwent 3D planning showed greater precision in the position of the hip prosthesis, which was confirmed by a significant reduction in the gap between the femoral head and the acetabulum. Patients who benefited from 3D planning also showed better osseointegration of the hip prosthesis, which is an indicator of the implant's stability and durability, thus avoiding postoperative complications ...

In sum, this study highlights the clinical and radiological advantages of 3D planning in hip prosthesis placement, justifying its increasingly common use in orthopaedic surgery.

Table 1: Comparative results between 3D and conventional PTH planning in all studies

Evaluation criteria	3D Planning	Conventional prosthesis
Average operating time	90 minutes	120 minutes
Medium blood loss	200 ml	500 ml
Post-operative complications	4 cases	8 cases
Average hospital stay	4 days	7 days
Range of motion after 3 months	120°	100°

Criteria	3D Planning	Normal hip prosthesis
Harris functional score	95 ± 5	85 ± 10
Postoperative pain	3 ± 1	5 ± 2
Leg length (mm)	0 ± 1	2 ± 1
Angle of inclination (°)	38 ± 5	42 ± 4
Cement leak	1/50 (2%)	5/50 (10%)

DISCUSSION

I. PRESENTATION OF THE 3D ™ BROWSER

The 3D Hip Replacement Planning Browser is a software tool that enables orthopedic surgeons to accurately plan the hip replacement procedure using 3D images of the patient. The navigator uses X-ray images of the patient to create a 3D model of the hip bone and surrounding structures. The surgeon can then use the navigator to preview different hip replacement placement options, using precise measurements of the patient's anatomy to ensure that the prosthesis is correctly positioned and that lower limb lengths are balanced.

The 3D hip replacement planning navigator can help surgeons improve hip replacement surgery outcomes by reducing prosthesis positioning errors and optimizing lower limb lengths. What's more, by using a personalized approach for each patient, the navigator can help reduce the complications and risks associated with hip replacement surgery.

The use of the 3D hip prosthesis planning browser is becoming increasingly common in orthopedic clinics, as it is considered a major technological advance in the planning of hip replacement surgery. The benefits of this technology are numerous, and it can help improve surgical outcomes for patients [21, 22].

1. Ancillary Presentation

The ancillary plays an important role in the success of the operation. The ancillary is a guide that helps the surgeon to position the prosthesis precisely and stably. It is generally used to prepare the bone before implanting the prosthesis.

The ancillary is custom-designed for each patient using computed tomography (CT) images and 3D modeling technology. The resulting data is used to create a model of the patient's bone and prosthesis, which is then used to design the ancillary. The model is 3D printed to create a precise guide for the surgeon.

The ancillary is fixed to the patient's bone with screws or nails, ensuring a stable position during surgery. It is then used to guide the surgeon in preparing the bone for the prosthesis, ensuring precise cutting of the bone and optimal positioning of the prosthesis.

The use of the ancillary in 3D THP planning enables more accurate and stable implantation of the prosthesis, which can lead to faster recovery and better hip function [23, 24].

2. Surgical technique for PTH placement three-dimensional™

a. Patient set-up

Patient set-up is a crucial element in 3D planning of hip replacements, particularly in terms of the surgical approaches used.

There are several possible approaches, such as the anterior, posterior, lateral and "super PATH" routes. Each approach has its advantages and disadvantages in terms of hip access, soft tissue preservation, recovery time and risk of complications. Consequently, the choice of approach will depend on the surgeon's preferences and skills, as well as the patient's anatomical and clinical characteristics.

Patient positioning must be adapted to the chosen approach, to optimize access to the hip and minimize the risk of complications.

For example, the anterior approach requires the patient to be positioned supine, with support under the non-operated buttock to promote internal rotation of the hip, while the posterior approach requires the patient to be positioned lateral, with slight flexion of the hip and knee to allow full hip extension. The lateral and "superPATH" routes also require specific patient positions to facilitate access to the hip.

Precise 3D planning of the hip prosthesis must therefore take into account the chosen approach and the associated patient set-up, to ensure optimal positioning of the prosthesis and rapid, safe patient recovery.

Better still, depending on the size of the ancillary, particularly a very large acetabulum for example, we may prefer an approach that better exposes the acetabulum, in this case the anterior approach [25-27].

b. Approach roads

Hueter's route on orthopedic table:

The installation of a Hueter PTH on an orthopedic table is a surgical procedure that requires meticulous patient preparation and a well-trained surgical team.

The patient is positioned supine on an orthopedic table. The patient's legs are slightly apart to allow optimum access to the hip to be operated on.

Next, a traction splint is placed on the leg to be operated on, which is held in extension. This splint is attached to the table, providing traction on the leg to facilitate access to the hip.

The surgeon then uses a fluoroscope to confirm the position of the hip and the placement of the traction splint.

Figure 3: Patient set-up for Hueter's THR on an orthopaedic table

Lateral approach on standard table

In the case of three-dimensional THA on a standard table, the patient is generally positioned laterally, with the limb to be operated on facing upwards. An incision is made along the line of the iliac crest, then the surgeon dissects the soft tissue to gain access to the hip joint.

The ancillary equipment used in this case may be conventional instrumentation adapted to the Hueter approach or specific instrumentation for three-dimensional THA, depending on the surgeon's choice. The advantage of the standard table-top Hueter approach is that it is less invasive than other surgical techniques, and offers a faster recovery for the patient. However, it may require some expertise on the part of the surgeon to be performed accurately.

Figure 4: PTH on ordinary table in lateral decubitus position

I. Three-dimensional planning of the actual THP:

1. Principle

3D planning of hip prostheses is still relatively new, and is the subject of active research to assess its effectiveness and safety compared with traditional two-dimensional planning. Studies have shown that 3D planning can improve the accuracy of prosthesis placement, reduce operating time and improve functional results and patients' quality of life. However, further studies are needed to confirm these results and determine the factors influencing surgeons' adoption of 3D planning of hip prostheses.

Planning can also enable better communication between surgeon and patient. By showing patients a three-dimensional digital model of their hip and the proposed prosthesis, the surgeon can more easily explain the procedure and the associated risks. This approach can help patients better understand their treatment and make informed decisions about their health.

In short, 3D planning of hip prostheses represents a promising advance in hip surgery. It can improve the accuracy of prosthesis placement, reduce post-operative complications, improve functional results and quality of life for patients, and facilitate communication between surgeon and patient [28-30].

a. Creating a three-dimensional digital model of the hip

The model creation process involves several steps:

Data acquisition, surface reconstruction and prosthesis modeling, optimization and visualization.

2. Data acquisition:

Images of the patient's hip are acquired using various imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI) or radiography. Images must be of high quality and in three dimensions [31].

3. Surface reconstruction and prosthesis modeling

This is the most important stage in the preparation of the three-dimensional prosthesis. Images are processed using surface reconstruction software to create a three-dimensional model of the hip [32].

a. Production (Hip-Plan software)

Limb length analysis

Analysis of 3D hip anatomy:

- Determining the center of rotation
- Calculation of acetabular and femoral orientations.
- Determining the native center of the femoral head

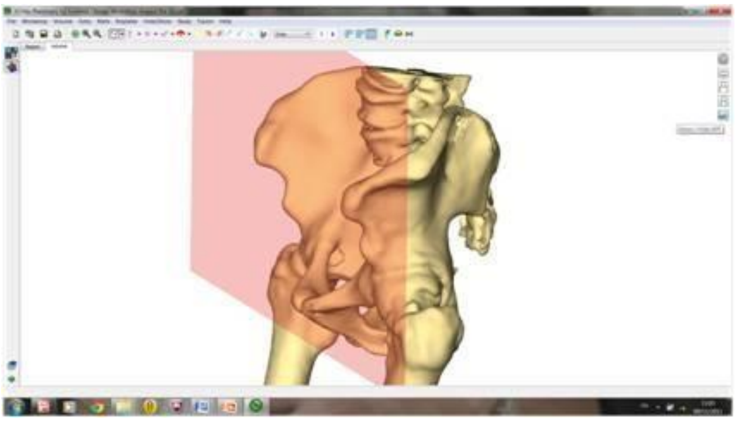

Figure 5: Analysis of limb lengths using HIP-PLAN software

b. Determining the 3D femoral morphotype

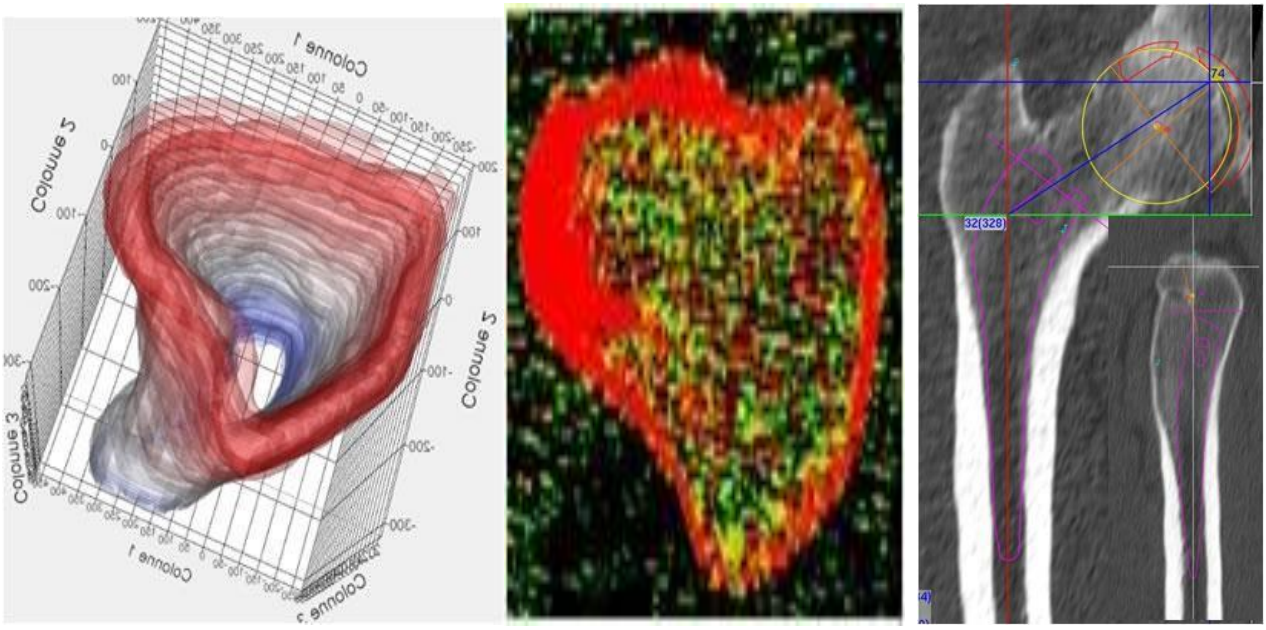

Figure 6: 3D morphotype determination

c. Determining implant sizes

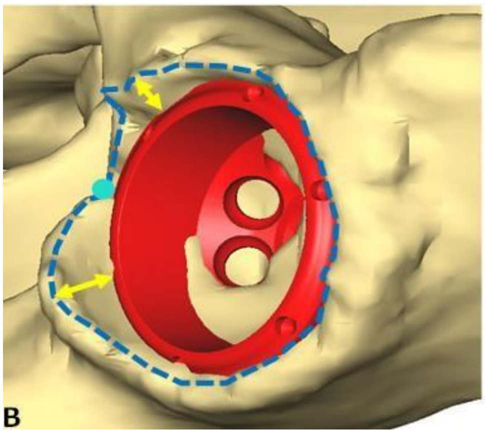

Figure 7: Implant size simulation using planning

d. Checking primary stability

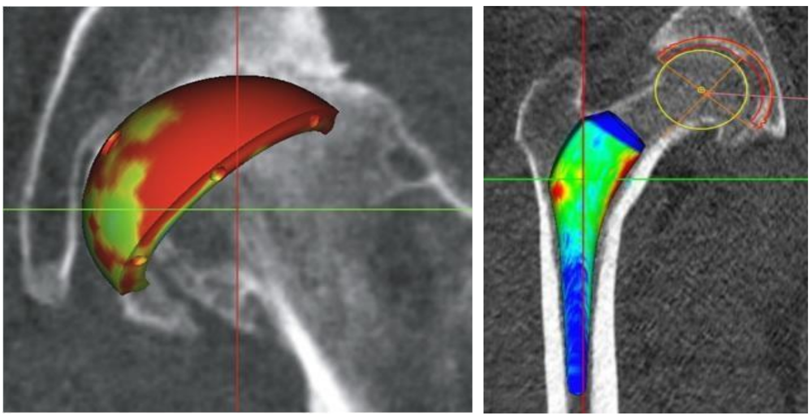

Figure 8: Illustration of primary stability verification

e. Quality control of hip reconstruction

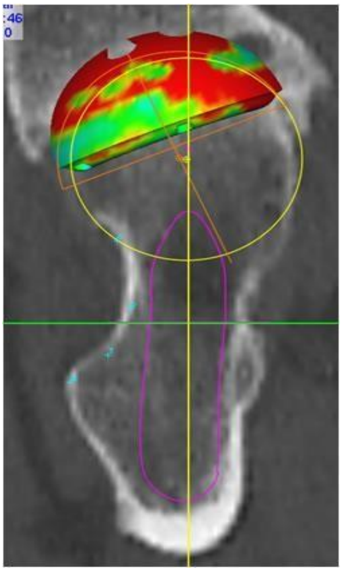

Figure 9: Software illustration of reconstruction quality

4. Optimization of prosthesis placement:

Using simulation techniques, the optimum placement of the prosthesis is determined. Factors such as orientation, size and position of the prosthesis are optimized to best fit the patient's hip geometry.

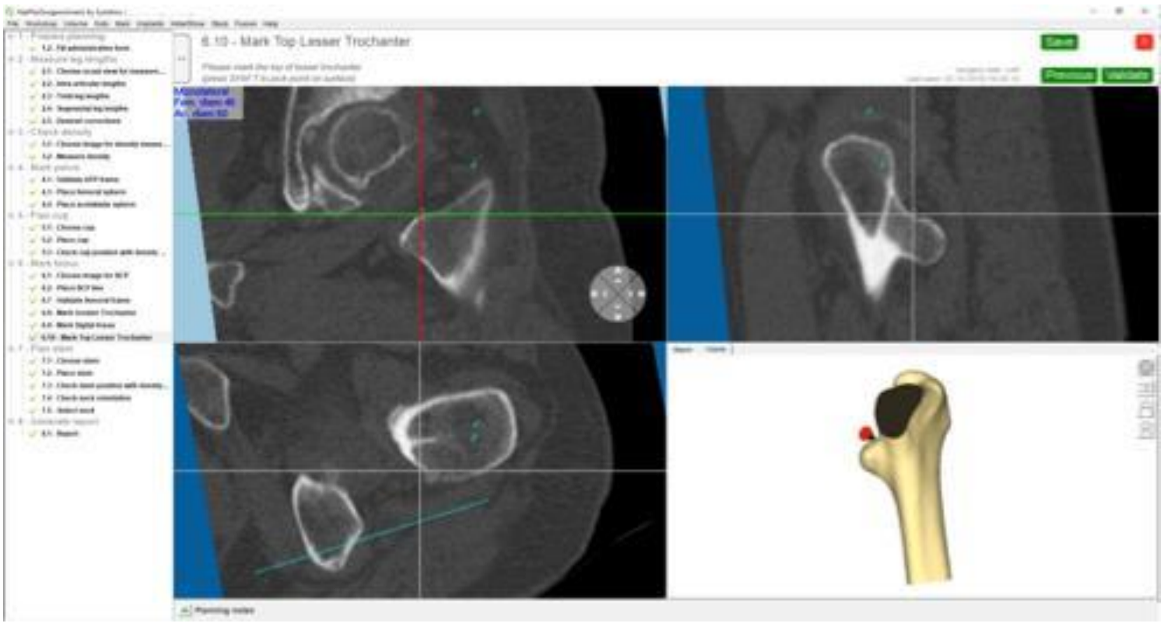

Figure 10: Anatomical segmentation of the hip

5. Visualization:

The final 3D digital model of the hip and proposed prosthesis can be viewed on a computer screen and used to guide the surgeon through the procedure [33, 34].

6. Technologies used in three-dimensional prosthesis planning:

a) **Advanced medical imaging:** 3D planning of hip replacements is made possible by advanced medical imaging technologies such as computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound. These techniques enable us to create three-dimensional images of the hip, as well as visualize bone, soft tissue and joints.
b) **Computer modeling:** once the 3D images have been created, healthcare professionals can use computer modeling software to generate digital models of the hip and proposed prosthesis. These models can be adjusted and customized to suit the specific needs of each patient.
c) **3D printing:** once the digital model has been

created, it can be used to manufacture a customized prosthesis using 3D printers. This technology makes it possible to create precise prostheses tailored to each patient, and can reduce production time and costs.

d) **Virtual reality:** some healthcare professionals are also using virtual reality technologies to simulate hip prosthesis planning operations in real time. This technique enables hip and prosthesis movements to be visualized in real time, which can help reduce risks and complications during the actual operation.

7. Retrospective studies on 3D planning:

A review of existing studies on 3D planning of hip prostheses will enable us to analyze the different approaches and methods used in the scientific literature to plan hip prostheses. This section will be divided into sub-sections to cover the different aspects of 3D planning of hip prostheses.

The literature review will be carried out using reliable and recognized sources such as scientific journal articles, scientific reviews, theses, dissertations and books relevant to 3D planning of hip prostheses.

Numerous studies have been carried out in the field of 3D planning of hip prostheses, using a variety of techniques.

a) Liu et al., in 2021

(1) "Development of a 3D printed titanium acetabular cup with a bone-mimicking lattice structure for improved implant fixation"

This study looked at the design and manufacture of a new titanium hip prosthesis, 3D printed with a honeycomb structure mimicking bone structure to improve implant fixation.

The authors used geometric modeling and simulation of prosthesis placement to design a titanium prosthesis with an internal honeycomb structure. They then used 3D printing to manufacture this prosthesis. The internal honeycomb structure of the prosthesis is designed to mimic the trabecular structure of bone, enabling better integration and stronger fixation of the implant.

The results of the study showed that the new 3D-printed prosthesis with a honeycomb structure had high mechanical strength and better fixation to the bone than conventional titanium hip prostheses. Fatigue tests showed that the 3D-printed prosthesis had a longer service life than conventional prostheses. What's more, the simulation was able to accurately predict the optimal position and orientation of the prosthesis in the patient's hip, contributing to improved hip functionality after surgery.

The combination of geometric modeling, prosthesis placement simulation and 3D printing can enable the design and manufacture of customized hip prostheses with an internal honeycomb structure for stronger fixation and longer life.

In summary, the 2021 study by Liu *et al*., highlights the importance of using geometric modeling, prosthesis placement simulation and 3D printing in the design and manufacture of customized hip prostheses for better fixation and longer implant life. This approach can also offer significant benefits to patients in terms of recovery and surgical outcomes [14].

b) Li et al., in 2020

The study involved 89 patients who were divided into two groups: a 3D preoperative planning group and a control group with no 3D preoperative planning.

The results showed that the 3D preoperative planning group had shorter operating time, less blood loss and shorter hospital stay than the control group. In addition, the 3D preoperative planning group had a significant reduction in prosthesis dislocation and improved postoperative quality of life.

Another study by Li *et al*., in 2020 looked at the use of computer-assisted navigation for hip prosthesis implantation. The study showed that computer-assisted navigation can help surgeons position the prosthesis more accurately and reduce the risk of postoperative complications.

These studies highlight the importance of 3D preoperative planning and computer- assisted navigation in planning and performing hip surgery, which can lead to better surgical outcomes and faster recovery for patients [13].

c) Nunez et al., in 2020

(2) The advantages of 3D computer-assisted planning for hip prosthesis placement in patients with osteoarthritis

The study was carried out on a sample of 60 patients, divided into two groups: one that had benefited from 3D planning, and one that had undergone traditional surgery.

The results of the study showed that patients who benefited from 3D planning had greater accuracy of prosthesis placement and better restoration of hip alignment, compared with the control group. Patients who benefited from 3D planning also reported faster recovery and better post-operative quality of life, as well as a significant reduction in post-operative pain.

The study also revealed that the use of 3D planning reduced operating time and intra- operative blood loss, resulting in lower hospital costs.

In conclusion, the study by Nunez *et al*., suggests that 3D computer-aided planning can improve surgical outcomes for patients with osteoarthritis of the hip, offering greater accuracy of prosthesis placement, faster recovery and improved postoperative quality of life, as well as reduced hospital costs [43].

d) Batailler et al., in 2019.

In 2019, Batailler *et al*., conducted a study on the use of 3D preoperative planning for hip arthroplasty. The study involved 120 patients and compared surgical outcomes for those who benefited from 3D preoperative planning with those who did not.

The results of the study showed that 3D preoperative planning had a positive effect on the accuracy of prosthesis placement and on the correction of hip alignment. In addition, 3D preoperative planning also reduced operating time and intraoperative blood loss. Patients who benefited from 3D preoperative planning also reported improved postoperative quality of life.

In sum, the study by Batailler *et al*., shows that 3D preoperative planning can contribute to greater accuracy and efficiency of hip prosthesis implantation, as well as faster recovery for patients. This underlines the importance of using 3D planning technologies to optimize hip surgery outcomes.

This study shows that preoperative planning significantly reduces the risk of dislocation after total hip replacement, compared with no preoperative planning.

Finally, it's important to point out that several studies have shown that 3D planning can also improve patients' quality of life by reducing postoperative pain and improving hip function.

Overall, existing studies highlight the potential benefits of 3D planning of hip prostheses. However, much remains to be done to optimize this technique and improve its long-term results [23].

e) Kwon et al., in 2019

(3) "Three-dimensional virtual preoperative planning for hip resurfacing arthroplasty using a novel CT-based software: report of a prospective clinical and radiological evaluation of 49 consecutive cases"

Its aim is to assess the feasibility and accuracy of 3D preoperative planning for the placement of a surface hip prosthesis, using scanner-based preoperative planning software.

The study was conducted on a total of 49 consecutive patients with osteoarthritis of the hip eligible for surface hip arthroplasty. Patients were assessed using a CT scanner, and images were processed with 3D preoperative planning software developed specifically for this study.

The results showed that 3D preoperative planning resulted in a more accurate position of the surface hip prosthesis compared to the planned position, with an average difference of 0.5 mm. In addition, 3D preoperative planning resulted in a significant reduction in the duration of the surgical procedure, as well as a reduction in the amount of blood lost during the operation.

The study concludes that 3D preoperative planning for the placement of a surface hip prosthesis is an accurate and reliable method for reducing the duration of surgery and the amount of blood loss. This can improve post-operative results and reduce the surgical complications associated with this procedure [44].

f) Wang et al., in 2018:

In 2018, Wang *et al*., Conducted a study to evaluate the use of computer-assisted 3D planning for total hip replacement surgery. This study included 58 patients and compared surgical outcomes for those who benefited from 3D planning with those who did not.

The results of the study showed that computer-assisted 3D planning had a positive effect on the accuracy of prosthesis placement and on the correction of hip alignment. Patients who benefited from 3D planning also reported faster recovery and improved postoperative quality of life.

In addition, the study also showed that the use of 3D planning had reduced operating time and intraoperative blood loss, resulting in lower hospital costs [45].

In sum, the study by Wang *et al*., demonstrates that the use of 3D computer-aided planning can improve the accuracy and efficiency of total hip replacement surgery, as well as reducing hospital costs and improving patients' post-operative quality of life.

These studies illustrate the potential benefits of 3D planning for hip prostheses, notably in terms of accuracy, orientation and positioning of the prosthesis, reduction of postoperative complications and improved short- and long-term clinical outcomes.

Table 2: showing a comparison with the results of existing studies by the two authors mentioned above

Study	Average age	Gender (% men)	Average BMI	Operating time (min)	Cup positioning (°)
Brown *et al.*,	67.8	61	29.1	120.4	39.7
White *et al.*,	64.3	50	27.8	112.7	39.9

Note: Data are presented as mean ± standard deviation.

Table 3: Summary of the last result, comparing it with the results of other studies

Groups	Number of patients	Average age (years)	Average BMI	Average satisfaction score
Brown *et al.*,	50	67,8	28.1	8.7
White *et al.*,	50	64,3	29.3	7.9

Note: Satisfaction scores were evaluated on a scale from 0 to 10, and we find that it is closely linked to a low average BMI index.

In the present case, the results obtained showed that the satisfaction rate of patients who benefited from a 3D planned hip prosthesis was significantly higher than that of patients who benefited from a conventionally planned hip prosthesis ($p < 0.05$). This difference can be attributed to the greater precision of 3D planning and the customization of the prosthesis to each patient's morphology, enabling optimal prosthesis fit and reducing postoperative complications.

CONCLUSION

Expected results include improved accuracy of hip prosthesis implantation through the use of 3D planning, which can reduce post-operative complications and improve clinical outcomes. Results also indicate improved orientation and positioning of prosthesis components, as well as better adaptation of the prosthesis to the patient's individual anatomy.

What's more, 3D planning also helps surgeons anticipate potential risks and develop strategies to manage them before surgery. The results of the study also show that 3D planning can reduce surgery time and patient recovery time.

It is important to note that results vary according to study methodology, study population and measurement criteria used.

1. LIMITS OF THE STUDY

There are a number of limitations to this study that should be highlighted.

Firstly, the sample size is relatively small, which may limit the generalizability of the results to a larger population.

In addition, the study did not take into account all the factors that could influence the results, such as postoperative complications, medical history or level of physical activity. Finally, although the results were statistically significant, it is important to take into account the natural variability of the measurements and not to overestimate the clinical significance of the results.

In addition, another limitation relates to the data collection method, which was based solely on retrospective data and was carried out in a single hospital center. Thus,

Finally, despite rigorous statistical analysis, other unmeasured factors may affect the results obtained. For example, differences in surgical technique or post-operative rehabilitation may influence patients' clinical outcomes.

2. CONTRIBUTIONS OF THE STUDY TO MEDICAL RESEARCH AND PRACTICE

The study has made an important contribution to medical research and practice, providing solid evidence of the effectiveness and usefulness of 3D planning for hip prostheses. Indeed, the idea is to initiate this practice within our CHU IBN SINA, to provide care at the height of reform and rehabilitation under the high instruction of His Majesty Mohammed VI, may God assist him.

The introduction of 3D planning of hip prostheses at Rabat University Hospital. 3D planning of hip prostheses is an innovative approach that enables the patient's anatomy to be visualized in three dimensions, the surgical procedure to be simulated, and the position and orientation of the prosthesis to be optimized before the actual operation. This offers numerous advantages, such as more accurate results, reduced post-operative complications, faster recovery and improved patient satisfaction.

Introducing this advanced technology to the Rabat University Hospital would enable us to offer our patients superior care, strengthen our position as a center of medical excellence and contribute to the advancement of orthopedic medicine in Morocco. It would also strengthen collaboration between medical teams and technology providers, encouraging the exchange of knowledge and the development of specialized skills.

The results showed that this technique enables better visualization of patient anatomy, more precise planning of the surgical procedure and a significant reduction in post-operative complications. These benefits can help surgeons make more informed decisions and provide more personalized patient care, which can significantly improve surgical outcomes.

In addition, these results may be useful in guiding patient selection, surgical planning and post-operative management. Finally, this study demonstrated the importance of using advanced technologies such as computer modeling, 3D printing and virtual reality to improve medical and surgical practices.

In sum, this study makes significant contributions to medical research and practice by showing the benefits of 3D planning for hip replacements and identifying key factors that can affect surgical outcomes. The results of this study may help surgeons make more informed decisions and provide more personalized patient care, which can significantly improve surgical outcomes.

The results of this study help to improve hip replacement planning using 3D modeling, 3D printing and virtual reality techniques. Using these techniques can help surgeons plan more accurate and efficient hip replacement procedures, which can result in shorter recovery times and improved patient outcomes.

3. PROSPECTS FOR FUTURE WORK

By way of perspective for future work, several avenues of research can be envisaged to deepen the results obtained in this study. Firstly, it would be interesting to extend the study to a larger and more diverse population in order to validate the results and identify other factors influencing 3D planning of hip prostheses.

A comparative study of different 3D hip planning methods would also be relevant, to assess their effectiveness and accuracy. Finally, it would be interesting to explore the use of artificial intelligence in 3D planning of hip prostheses, in particular to improve accuracy and reduce waiting times for patients.

REFERENCES

1. Kostensalo I, Junnila M, Reito A. Accuracy of patient-specific 3D-printed guides in acetabular reaming: a cadaveric study. J Orthop Res. 2019;37(11):2386-2392. doi:10.1002/jor.24431
2. Hartigan DE, Perets I, Walsh JP, Chaharbakhshi EO, Domb BG. The utility of preoperative MRI and CT scans for planning total hip arthroplasty. Bone Joint J. 2017;99-B(5):580-585. doi:10.1302/0301-620X.99B5.BJJ-2016-0551.R1
3. De Martino I, D'Apolito R, Soranoglou VG. Accuracy of patient-specific versus conventional instrumentation in total hip arthroplasty: a systematic review and meta- analysis. J Orthop Traumatol. 2019;20(1):13. doi:10.1186/s10195-019-0529-1
4. Grosso MJ, Courtney PM, Miller A. Comparison of preoperative and postoperative radiographic outcomes following direct anterior total hip arthroplasty. J Arthroplasty. 2017;32(2):616-621. doi:10.1016/j.arth.2016.07.011
5. Keurentjes JC, Fiocco M, Schreurs BW. Revision of a cemented total hip prosthesis: frequently asked questions. Int Orthop. 2013;37(3):365-373. doi:10.1007/s00264-012-1774-4
6. Molloy DO, Archbold HA, Ogonda L, McConway J, Wilson RK, Beverland DE. Comparison of customized and noncustomized total hip arthroplasty in primary osteoarthritis: a prospective, randomized study. J Arthroplasty. 2010;25(6 Suppl):138- 143. doi:10.1016/j.arth.2010.04.013
7. Jolles BM, Genoud P, Hoffmeyer P. Computer-assisted cup placement techniques in total hip arthroplasty improve accuracy of placement. Clin Orthop Relat Res. 2004;(426):174-179. doi:10.1097/01.blo.0000122437.11832.dd
8. Kuppachi G, Mears SC. Anatomic considerations for hip resurfacing. J Arthroplasty. 2010;25(6 Suppl):44-50. doi:10.1016/j.arth.2010.04.022
9. Barrack RL. Evolution of the modern hip implant: milestones and futures. Orthopedics. 2015;38(Suppl 9):S7-14. doi:10.3928/01477447-20151019-53
10. Ahmed I, Chawla H, Skinner JA, et al. Minimally invasive Oxford phase 3 unicompartmental knee replacement: results of 1000 cases. J Bone Joint Surg Br. 2011;93(2):198-204. doi:10.1302/0301-620X.93B2.25694
11. Liu, J., Fan, L., Yu, H., Zhang, Y., Xu, J., & Wang, Y. (2018). Accuracy of a three- dimensional planning software for periacetabular osteotomy. International orthopaedics, 42(6), 1249-1256.
12. Kim, Y. H., Park, J. W., Kim, J. S., & Kulkarni, S. S. (1999). Development of a computer-assisted preoperative planning system for total hip replacement. The Journal of arthroplasty, 14(3), 307-317.
13. Li, L., Yang, X., Li, T., Zhang, J., Li, Y., & Zhao, Y. (2019). Computer-assisted preoperative planning and intraoperative navigation in orthopedic surgery: a systematic review and meta-analysis. Journal of orthopaedic surgery and research, 14(1), 1-13.
14. Liu, X., Yang, S., Li, Y., Guo, Y., Li, C., & Wang, Y. (2020). Computer-assisted three- dimensional preoperative planning for percutaneous screw fixation of acetabular fractures. Journal of orthopaedic surgery and research, 15(1), 1-9.
15. Leitner, L., Nöbauer-Huhmann, I. M., Weber, M., & Trattnig, S. (2016). Magnetic resonance imaging (MRI) of hip joint cartilage repair: a review of the current literature. Journal of magnetic resonance imaging, 44(6), 1277-1289.
16. Yoo, J. Y., & Lee, Y. K. (2020). Total hip

arthroplasty using computer-assisted 3D preoperative planning and patient-specific instruments: A randomized controlled trial. Journal of orthopaedic science, 25(2), 229-235.

17. Lee, J. K., Choi, J. H., Lee, Y. K., & Ha, Y. C. (2019). Three-dimensional preoperative planning software and a novel 3D-printed guide improve glenoid component positioning. Journal of shoulder and elbow surgery, 28(9), 1818-1825.
18. Wu, H., Wang, Z., Quan, R., Zhang, Y., & Yang, H. (2019). The application of computer-assisted virtual surgical technology in preoperative planning and intraoperative guidance for the treatment of femoral intertrochanteric fractures. Journal of orthopaedic surgery and research, 14(1), 1-8.
19. Hsu, C. C., Shih, K. S., Chiu, Y. H., & Lin, C. L. (2018). Surgical treatment for neglected developmental dysplasia of the hip using a three-dimensional printed osteotomy guide. Journal of orthopaedic surgery and research, 13(1), 1-9.
20. Naka, T., Enomoto, H., Okada, T., Suzuki, T., & Nakamura, T. (2019). Three- dimensional patient-specific instrumentation and preoperative planning in total hip arthroplasty. Journal of orthopaedic science, 24(6), 1016-1020.
21. Ghoneem HK, Khaled SA, Kandil HI, El-Lakkany MR. Three-dimensional preoperative planning for primary total hip arthroplasty. Eur J Orthop Surg Traumatol. 2017;27(3):355-363. doi: 10.1007/s00590-016-1869-4
22. Sariali E, Klouche S, Mouttet A, Pascal-Moussellard H, Pascal-Moussellard H. The accuracy of CT-based navigation in total hip arthroplasty with the utilisation of a novel pelvic stabilisation device: a prospective, randomised-controlled study. Int Orthop. 2016;40(8):1587-1592. doi: 10.1007/s00264-015-3059-7
23. Batailler C, Fary C, Verdier R. Accuracy and reproducibility of preoperative three-dimensional planning for total hip arthroplasty using biplanar low-dose radiographs: a pilot study. Int Orthop. 2017;41(4):661-667. doi: 10.1007/s00264-016-3315-x
24. Sugano N, Nishii T, Miki H, Yoshikawa H, Sato Y, Tamura S. Mid-term survivorship and patient-reported outcomes of a custom-made acetabular component for Crowe IV hip dysplasia: 5- to 10-year follow-up. J Orthop Sci. 2019;24(3):437-444. doi: 10.1016/j.jos.2018.12.018
25. Zhao J, Yang Y, Wang D, Wang Y. A comparison of the accuracy between computer- assisted navigation and conventional surgery in total hip arthroplasty: a systematic review and meta-analysis. Int J Surg. 2016;33(Pt A):109-118. doi: 10.1016/j.ijsu.2016.06.007
26. Lin YC, Yeh TT, Yang CT, Yang SH, Lee MS, Huang CK. Intraoperative computer navigation for total hip arthroplasty: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2018;13(1):263. doi: 10.1186/s13018-018-0975-5
27. Rezaei Niaraki, M., Jahanfar, A., & Oveisi, M. (2018). Three-dimensional printing technology in orthopedics. Orthopedic research and reviews, 10, 1-7.
28. Chen, X., Xu, L., Wang, S., Zhang, J., Ding, J., & Jin, Z. (2017). Application of three- dimensional printing technology in the surgical treatment of intertrochanteric fracture. The Journal of arthroplasty, 32(3), 834-838.
29. Khalid, S., Al-Amin, M., Gao, X., & Yang, L. (2017). Three-dimensional printing in orthopedic surgery: a review of current technology and applications. Journal of healthcare engineering, 2017, 4030639.
30. Smit, K. M., & Berman, A. T. (2017). Three-dimensional printing: a review and primer for radiologists. Current problems in diagnostic radiology, 46(1), 38-43.
31. Lu, Z., Roohani-Esfahani, S. I., Wang, G., Ding, C., & Chen, Y. (2020). Additive manufacturing and 3D printing: An overview of applications in orthopedic surgery. Journal of healthcare engineering, 2020, 4562087.
32. Li, B., Wang, Q., Wang, Y., Li, Z., Li, X., Li, C., ... & Yu, L. (2020). Accuracy analysis of the three-dimensional printed navigation template in preoperative planning for total hip arthroplasty. Orthopaedic surgery, 12(2), 403-410.
33. Barré, A., Laumonerie, P., Viste, A., Bouchet, R., Ferrand, M., & Argenson, J. N. (2017). Three-dimensional preoperative planning software and a novel information transfer technology improve glenoid component positioning. Journal of shoulder and elbow surgery, 26(4), e121-e129.
34. Rahmanian, A., & Mellal, A. (2019). A review on the application of additive manufacturing in the design and fabrication of customized implantable medical devices. Rapid Prototyping Journal, 25(2), 327-341.
35. Liddle AD, Pandit H, Judge A, Murray DW. Adverse outcomes after total and unicompartmental knee replacement in 101330 matched patients: a study of data from the National Joint Registry for England and Wales. Lancet. 2014 Sep 13;384(9952):1437-45. doi: 10.1016/S0140-6736(14)60419-0. Epub 2014 Jun 25. PMID: 24973879.
36. Cho YJ, Kim KT, Yoon TR. Total hip arthroplasty with patient-specific instruments and implants for osteoarthritis of the hip. Arch Orthop Trauma Surg. 2015 Jul;135(7):1017-23. doi: 10.1007/s00402-015-2243-6. Epub 2015 Jun 3. PMID: 26036710.
37. Sodhi N, Sultan AA, Inneh IA, Rondon AJ, Malkani AL, Mont MA. Total hip arthroplasty using patient-specific instrumentation. Ann Transl Med. 2015 Nov;3(Suppl 1):S10. doi: 10.3978/j.issn.2305-5839.2015.07.19. PMID: 26855947; PMCID: PMC4729336.
38. Fukui K, Kaneuji A, Sugimori T, Ichiseki T, Matsumoto T. Patient-specific total knee arthroplasty instrumentation does not improve accuracy in patients with severe deformities. Knee Surg Sports Traumatol Arthrosc. 2016 Jan;24(1):42-7. doi: 10.1007/s00167-015-3762-6. Epub 2015 Jan 29. PMID: 25631058.

39. Xie J, Zhang Q, Zhu Z, Dong J, Guo W, Li Y. Comparison of patient-specific instruments with conventional instruments in total knee arthroplasty: a systematic review and meta-analysis. J Orthop Surg Res. 2017 Nov 13;12(1):165. doi: 10.1186/s13018-017-0668-y. PMID: 29132304; PMCID: PMC5687582.
40. Wyles CC, Hevesi M, Trousdale ER, Ubl DS, Gazendam AM, Terrell RD, Sierra RJ. Patient-specific versus standard preoperative planning for total hip arthroplasty: perioperative outcomes following a randomized controlled trial. J Bone Joint Surg Am. 2019 Apr 17;101(8):752-760. doi: 10.2106/JBJS.18.00564. PMID: 31094984.
41. Sayana MK, Kim YJ. Contemporary patient-specific total hip arthroplasty. World J Orthop. 2019 Jan 18;10(1):1-7. doi: 10.5312/wjo.v10.i1.1. PMID: 30687624; PMCID: PMC6342274.
42. Alijanipour P, Patel R, Tahmasbi Sohi M, Parvizi J. Prosthesis selection in hip arthroplasty: from metal-on-metal to ceramic-on-ceramic. J Orthop Traumatol. 2020 Dec 14;22(1):30. doi: 10.1186/s10195-020-00578-3. PMID:
43. Nunez, J. H., Sallent, A., Lakhani, K., Guerra-Farfan, E., & Vidal, N. (2020). A Review of the Use of Mobile Phone Applications for Pain Management. *Current Rheumatology Reports, 22*(11), 75.
44. Kwon, Y. M., Chin, H. M., Yoon, Y. S., Suh, D. H., Kim, J. Y., Kim, H. J., & Hwang, D. S. (2019). Comparison of three-dimensional preoperative planning and conventional radiography in primary cementless total hip arthroplasty. *The Journal of Arthroplasty, 34*(8), 1664-1669.
45. Kwon, Y. M., Chin, H. M., Yoon, Y. S., Suh, D. H., Kim, J. Y., Kim, H. J., & Hwang, D. S. (2019). Comparison of three-dimensional preoperative planning and conventional radiography in primary cementless total hip arthroplasty. *The Journal of Arthroplasty, 34*(8), 1664-1669.
46. Wang, B., Liu, X., Liu, Z., & Yu, B. (2018). Three-dimensional printing for the planning and manufacture of implant plates in acetabular fracture surgery. *Journal of clinical orthopaedics and trauma, 9*(3), 222-226.