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Literature Review

Influence of Total Hip Replacement, Kinematic Analysis and Spatiotemporal Parameters: A Literature Review

Stephanie Fournex*

Podiatrist, NMC Healthcare Hospital, UAE

***Corresponding Author:** Stephanie Fournex, Podiatrist, NMC Healthcare Hospital, UAE.

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Abstract

Total hip replacement is indicated for lesions of the hip joint, in order to restore normal joint mobility, reduce pain and reduce functional impairment. In this analysis of the literature, we wanted to highlight the different influences of the total hip prosthesis, by an analysis of the kinematics and the spatio-temporal parameters. We selected 21 articles, with the gait parameters of which were recorded preoperatively up to one year and compared with a control group of healthy subjects. The results show us that the patients' gait improves up to 12 months postoperatively but does not reach the values of the control group of healthy subjects.

Keywords: *Total Hip Arthroplasty Gait Analysis; Activity Walk; Biomechanics Surgical Approaches Lower Limb*

Abbreviations

THA: Total Hip Arthroplasty; LA: Lateral Approach; PA: Posterior Approach; AA: Anterior Approach; AL: Anterolateral Approach; PL: Posterolateral Approach; FLT: Facia Lata Tensor; EIAS: Anterosuperior Iliac Spine; ROM: Range of Motion; BMI: Body Mass Index; LLD: Leg Length Discrepancy

Introduction

Walking is an innate means of locomotion for humans; it consists of a succession of cycles of steps (double and single support) allowing the body to move in a given direction. This activity requires different acquisitions at the physiological level: first of all, the maturity of postural control. Systems vestibular, proprioceptive and cerebellar are necessary to guarantee a good stabilization of the person and a coordination of his movements. To walk, humans must also be able to propel themselves forward and support their weight while standing. This implies a maturity of the muscular and bone system.

When walking, different joints will then be brought into play: the tarsal joints (subtalar, talonavicular, calcaneo-cuboid...) They allow small movements reducing the constraints of the foot during the different phases of walking. The talocrural joint stabilizes the upright position and allows for ankle flexion and extension movements. Higher up we find the knee, a supporting synovial joint, supporting the weight of the body when walking and also strong constraints. It will be supported by different meniscal, articular, ligamentous and muscular structures allowing the subject to physiological flexion and extension movements of this joint.

The coxofemoral joint is an enarthrosis that joins the femoral head and the acetabulum of the iliac bone. These two bone ends are covered with a layer of cartilage allowing smooth and painless movement in all three planes. This osteoarthritis is surrounded by a capsule and is reinforced by ligaments (four in number). Inside the capsule lines the synovial membrane containing a fluid reducing friction and premature wear of the joint. The joint can be damaged by different causes, so consider a hip prosthesis.

In 1941, the American Mc Kee created the first cementless total hip replacement (THA). Over the past 50 years, significant improvements in surgical techniques and implants have been achieved. The main goal of total hip replacement is to restore normal joint mobility, while minimizing pain and functional impairment due to joint limitation.

Nowadays, this surgical device making it possible to treat many hip pathologies has become commonplace for surgeons. The injured femoral head is replaced with a rod implanted in the femur and a cup in the acetabulum of the iliac bone. These materials can be metal, plastic, ceramic... It will be important to have a friction coupling between these two materials in order to minimize the coefficient of friction allowing fluidity in the movements.

One of the main indications for this surgery is osteoarthritis. In France, thousands of people suffer from hip osteoarthritis. This number keeps increasing every year. In 2010, the Technical Agency for Information on Hospitalization (ATIH) estimated the THA ratio for Western Europe at 226.4/100,000 hips [4].

Despite technical advances, many debates are raised to know the best surgical approach; one that will minimize instabilities, pain, muscle and tendon damage postoperatively, allowing patients to quickly return to normal function of the replaced limb. In this review of the literature, we looked at 5 different approaches.

The first, the lateral approach (L.A.), gives excellent exposure of the acetabulum increasing the quality of the cut and reduces the risk of postoperative instability and dislocation, as the posterior capsule is preserved. A first incision will be made above the greater trochanter, then between the Gluteus maximus and the body of the Fascia Lata Tensor (FLT). The gluteus maximus and medius will be detached, and the capsulectomy will be done anteriorly. This approach is often associated with weakness of the abductors and lameness secondary to the cutting of the gluteus medius and possible damage to the superior gluteal nerve.

The posterior approach (P.A.): The external rotators and the posterior capsule are detached from the back of the femur. The extent of muscle released distally in this approach includes in some cases the quadriceps, piriformis, and gluteus maximus. The lower capsule is released to allow better exposure of the acetabulum. The surgeon should keep the integrity of the hip abductors as much as possible and minimize damage to the sciatic nerve to avoid weakness and lameness.

During the anterior approach (A.A.), the patient is supine. On an imaginary line from the Anterior Superior Iliac Spine (ASIS) to the head of the fibula, the incision begins 2 cm behind it and ends at the greater trochanter. The surgeon excises the Fascia Lata Tensor (FLT) and detaches its aponeurosis, then replicates the same operation with the rectus femoris. The only tendon severed is the TFL. There is a risk of injury to the inferior gluteal nerves, the femoral and the lateral skin of the thigh. A minimally invasive approach exists: the capsule is damaged intramuscularly: between the Sartorius and the FLT or between the Gluteus and the FLT which remains lateral and the Sartorius and femoral rectus medially; thus, avoiding muscle damage. An L-shaped incision is made on the capsule and the hip is dislodged anteriorly.

For the anterolateral approach (A.L.), the patient is in lateral decubitus with sacral and pubic support. The incision is centered on the greater trochanter. First, we cut out the Fascia lata Tensor and the Gluteus maximus. In a second plane, the gluteus medius and the vastus lateralis of the quadriceps are visible and dissected. These two tendons will be detached from the greater trochanter in order to dislocate the head of the femur. The capsulectomy is done in a T-shape and the head of the femur is dislocated forward. The external rotators are not detached. The minimally invasive approach known as: “MALLORY approach”: allows the preservation of the abductors.

The posterolateral approach (P.A.R.), the patient will be installed in strict lateral decubitus. The surgeon locates the postero-superior edge of the greater trochanter and incises the skin-fatty tissue until it reaches the muscle fibers of the gluteus maximus. The incision runs deep as well as the bottom of the TFL which will also be cut across its grain. From there appears the second muscular plane: gluteus medius and square femoris, these muscles will have to be incised to reveal the muscles of the pelvic trochanteric 3rd muscular plane to be incised at the same time as the capsule in order to promote the closure. The medical team will save the piriformis tendon and locate the sciatic nerve so as not to continue the capsulectomy in its direction. The patients in this study we chose to combine two fields: surgery and podiatry. To explain the influence of surgical approaches to THA on the kinematics (Sagittal/Frontal/Transverse plane ROM) of four joints of the lower limb: Pelvis, Hip, Knee, Ankle. We will then confront the influence of the different approaches on the spatio-temporal parameters. We will compare the differences in approach based on preoperative data up to 1 year.

Aim of the Study

Our goal will be to put in place a practical tool available to paramedical practitioners allowing them to gain insight into the kinematic characteristics and spatio-temporal parameters of their patients who have undergone a first THA.

Materials and Methods

Literary research strategies

A search for articles on the kinematics of the lower limb after the installation of a total hip replacement was performed. A list of key words and terms were used (Total hip will be dislocated in adduction flexion and internal rotation. With the knowledge acquired today about the human body, we believe that the medical and paramedical professions must unite to best preserve the autonomy of the patient.

Hip Arthroplasty - Gait analysis - Activity - Walk - Biomechanics - Surgical approaches - Lower limb - Kinematic). We then randomly combined these words to obtain appropriate studies in the following databases: Pubmed, The Cochrane Library and Science Direct. Search filters were also applied, in particular: publications less than 10 years old.

Here are two examples of combinations made for item research. In pubmed, for the "THA" (24,215 results) "gait analysis" combination, 251 results are counted, then "walk" is added to obtain 89 results. We apply the filters to publications less than 10 years (68 results) and less than 5 years (44 results). For "THA" (24215) + "surgical approach" (1717) + "Kinematic" (84 results) we apply the filter publications less than 10 years old (64 articles). The article search by title was completed in December 2014 and there was a total of 78 studies.

Selection criteria

In order to allow a comparison between the different selected articles, a series of Inclusion and exclusion criteria were decided. We first chose to exclude articles with an average patient age of over 70 years. We believe that this type of patient mainly has reduced physical activity, this could play a negative role by preventing the proper progress of their postoperative rehabilitation and therefore adversely influence the evaluation of walking. Patients with previous THA are excluded because we want to study the influence of a first surgical experience on patients. Therefore, we are also eliminating all studies in which patients have bilateral THA. Our final exclusion criterion is the treadmill analysis. We believe that this device can influence various parameters such as the walking speed, or the balance of the patient.

We decided to include postoperative information up to 1 year in our study; no surgical approach has been ruled out. Articles should provide information on at least one of the following four joints: Pelvis, Hip, Knee, Ankle. The presence of a control group, an analysis on the contralateral limb, or a preoperative analysis is necessary in order to be able to compare the different results with each other.

Data extraction and analysis

Our second step in selecting articles was done after reading the abstracts from a PICO table. In which we had listed various information taking into account the criteria of inclusions and exclusions chosen (presence of the control group, age, BMI, sex of the patients, surgical approaches carried out, analysis in 3D walking lane, joints studied, etc.) After having eliminated irrelevant studies, 43/78 articles are guaranteed to be further searched. These 43 articles were then obtained in hard copy. We then proceeded to read the articles in full: three articles are excluded because no surgical approach is specified. Four articles compared pre- and postoperative differences using subjective questionnaires to patients. Two items are excluded because their measurements were made on a treadmill. One study did not exclude patients with other involvement of one or more joints. After reviewing the references of all these paper articles, an additional article was added. In view of the amount of information to be processed, we then decided to focus our study on the articles analyzing the patient's approach preoperatively, at 3 months (half-time for rehabilitation), 6 months (end of rehabilitation of after Perron., *et al.* (2000) [13]). A total of 21 articles were analyzed in this literature review. We then determined a set of fifteen questions that we would like to answer in this review. These questions will be detailed in the next "results" section.

Results

First, the results were obtained by performing percentages in order to better understand the distribution of each patient in the different approaches.

Patient characteristics

Number of patients

Of the 21 articles used for this literature review, 5 could not be fully exploited because information about the patients (age, number, sex, BMI, etc.) was not shared with us. Out of all of our articles, we have listed 610 patients divided into 5 surgical approaches: 90 patients for the lateral approach, 98 anterior approach, 127 posterior approach, 151 anterolateral approach and 144 for the posterolateral approach. The control group is made up of 180 healthy patients. For 5 articles, 131 patients of different approaches had an analysis on the leg contra-lateral to the lesion.

Gender, age and BMI of patients

Of the 610 patients, there are 282 women (46.22% of the total population) and 179 men (29.34%). For 149 patients the sex was not indicated in the studies. The control group is made up of 95 women (52.7% of the control population studied) and 60 men (33.3% of the group). For 25 people the sex is not stipulated.

The average age of the control group is 59.5 years. No patient is under 45 years old. 5.5% of subjects are in the 45 - 50 age group, 18.8% between 50 - 55 years, 11.1% between 55 - 60 years. The majority of people studied are between 60 - 65 years old: 36.6% and 27.7% in the 65 - 70-year age group.

The lateral approach is on average 62 years old. The youngest patients are between 55 - 60 years old: 20% of the group population. 35.5% are between 60 and 65 years old and 44.5% are between 65 - 70 years old. 57.7 Years is the average age of patients for the previous approach: 8% of patients between 50 - 55 years, 35.7% between 55 - 60 years, and the majority of patients 56.1% are between 60 - 65 years. For the posterior approach (mean = 57 years) no patient is less than 45 years old. 7.8% are in the 45 - 50 age bracket, 19.7% are between 50 - 55 years old, 33% between 55 - 60 years old, 22% between 60 - 65 years old and 17.3% are over 65 years old.

The average age of the anterolateral group is 58.3 years. 4.6% of patients are between 50 and 55 years old, 55.6% between 55 - 60 years old, 39.7% are in the 60 - 65 years age bracket.

To complete our last group studied, the posterolateral approach has an average age of 59.9 years. 21.5% of patients are under 50 years old. 26.4% are in the 55 - 60 age group, 34.7% between 60 - 65 years and 13.8% are between 65 - 70 years old. Next, let's move on to the body size of the patients (BMI) for each surgical approach. The mean BMI of the control group is 25.18 kg/m^2: 69.4% of patients have a BMI between 20 and 25 (ideal weight) and 30.5% between 25 and 30 (overweight). Patients in the lateral approach have an average BMI of 27.17 kg/m^2, they all have a BMI between 25 - 30. For the anterior approach, 64.2% of patients have a BMI between 25 - 30, the remaining 35.8% are in the 30 - 35 range. The average for this group is 29.6 kg/m^2.

27.26 kg/m^2 is the average body mass index of the posterior group. 100% of patients are in the 25 - 30 (overweight) bracket. The anterolateral approach has an average BMI of 28.16 kg/m^2, 6.6% of patients have an ideal weight. 58.9% are overweight and 14.5% the BMI is between 30-35. For 30 patients (24.37%) the BMI is not known (Cichy, Wilk, and Śliwiński, 2008) [....] For the posterolateral group the average BMI is 26.54 Kg/m^2, 29.8% of the population have an ideal weight (between 20 - 25) against 70.1% being overweight (BMI between 25 and 30 kg/m^2).

Indication of PTH

This analysis was carried out on 610 patients: Meneghini., *et al*. [10] did not differentiate the proportion of patients suffering from osteoarthritis and hip dysplasia, these 23 (3.77%) patients were then not taken into account for this analysis. The main cause of PTH is osteoarthritis present in 530 patients (86.8%), followed by all causes except fractures, infections, and revisions: 3.27%. All causes except osteoarthritis and ILMI, also account for 3.27% of patients. In third place come hip dysplasias for 14 patients, or 2.29% of the patients studied. 3 patients suffer from osteonecrosis (0.49%).

Surgical approaches

The 5 surgical approaches analyzed are those which appear most often in the literature. For our study, the anterolateral approach is the most represented: 24.75% of patients. Then follows the posterolateral approach (23.6%), posterior (20.8%), the anterior approach (16%) and finally the lateral approach for 90 patients (14.75%). The description of the implants used to replace the defective hip is precise for 18 articles, i.e., 516 patients. For the other 94 patients we do not know the type of implants used for the surgery.

Study design

Here we are trying to find out after how long the patients were analyzed.

Preoperative: Analysis carried out at 381.

- 3 months: 183 patients.
- 6 months: 249 patients
- 12 months: 261 patients.

Finally, we calculated the distribution of patients for each joint, regardless of the approaches used and the time at which the analysis was performed. The maximum number of patients analyzed is for the hip joint: 524 patients. For the pelvis, we have 273 patients analyzed. The knee 237 subjects and the ankle: 105 patients.

Cinematic

The results for the control group are noted in Annex. When an article in the co group gives us information about a joint we consider this value as the norm for our study.

Pelvis

For the kinematics of the pelvis, 92 patients were analyzed. Our results show difference values between the surgical approaches for the same precise period. This is explained by the fact that some authors have recorded range of motion: Bennett., *et al*. (2006) [3]; Miki., *et al*.

(2004) [11]; Reininga., *et al*. (2013) [19] while Lugade., *et al*. (2010) [8] speak of position in midstance. For the pelvic obliquity, negative values correspond to the drop of the pelvis, and the positive ones to its elevation. Only the variance for the article by Miki., *et al*. (2004) [11] could be obtained. A difference in the results for the limb contralateral to the lesion is observed for pelvic rotation (5.15) and for pelvic tilt (1.22). We can conclude that overall an improvement in the gait is observed at 1 year.

Hip

For the hip joint 379 patients were studied in the three planes, during a period of one year. Let us start with the movements present in the sagittal plane. The authors calculated different parameters depending on what interested them for their study: heel attack hip flexion, flexion/extension ROM, hip flexion or extension. Preoperatively, in general, the different patients in each study show a very close range of amplitude except for three authors Bennett., *et al*. (2006) [3], Klausmeier., *et al*. (2010) [7] and Miki., *et al*. (2004) [11]. For the lateral approach. Queen., *et al*. (2011) [16] calculated the hip flexion of her patients during heel strike. He finds a result of 32.18° (11.47). Pospischill., *et al*. (2010) [14] show the amplitude in hip flexion: 34.5° and during extension we observe that the hip remains at 10° of flexion. At 3 months, the flexion decreases: 30° and the extension increases: 1.5° of flexion. At 6 months, only the 20 patients from Beaulieu., *et al*. (2010) [2] gave a hip ROM value of 40.7°. At 1 year postoperatively, Queen., *et al*. (2014) [15] and Varin., *et al*. (2013) [21] provide us with information on hip kinematics in the sagittal plane. The first gives a value of 35.81° on the operated limb against 39.44° on the healthy unoperated limb. The second calculates a range of motion of 41.8° for his operated limb.

For the anterior approach, 43 patients are studied preoperatively to one year postoperatively. Overall, we observe an improvement in amplitude over time of analysis. The ROM value for Klausmeier., *et al*. (2010) [7] preoperatively is lower than the other values because the posterior approach includes 73 patients. We observe an improvement in the results 1 year postoperatively compared to the results obtained preoperatively.

For the anterolateral and posterolateral approaches an increase in particular amplitudes is observed after the installation of the total hip prosthesis. For the frontal plane, the authors calculated preoperatively results for each approach with the exception of the posterolateral approach. No analysis is done for 3 months. In general, we find that the results improve over time postoperatively.

For the transverse plane, few authors have studied kinematics. For the lateral approach, only Varin., *et al*. (2013) [21] performed an analysis 12 months postoperatively. During the propulsion phase the operated hip is in a position of 0.5° (3.8) in…. At 3 months postoperatively, no author has analyzed the kinematics of the joint. There is also no preoperative analysis for the posterolateral approach and at 6 months for the anterolateral and posterolateral approach. We observe that the results improve postoperatively.

Knee

Only 6 authors performed analyzes on the kinematics of the knee for the given time periods. 60 patients were analyzed preoperatively. At 3 months and 6 months, the analysis was carried out on 37 patients. One year after operation 103 were studied. For each approach, we observe an improvement in the range of motion in the sagittal plane except for the article by Foucher., *et al*. (2012) [6] where the amplitude is seen to decrease by 1° at 12 months compared to its value preoperatively.

At 12 months postoperatively, each patient is close to the values of the control group. Except for the posterior approach Miki., *et al*. (2004) [11] which remains preoperative up to 12 months below the values of the control group. For a given period, the range of values between the different approaches for the range of motion in the sagittal plane is large. Preoperatively, for example, the minimum ROM is for the posterior approach (41.5° (Miki., *et al*. 2004) [11]) the maximum for the anterolateral approach (61° (Foucher., *et al*. (2012) [6]). This is also observed at the other periods of gait analysis. The variance of the results could be calculated for Miki., *et al*. (2004) [11] and Agostini., *et al*. (2014) [1]. We observe a large difference between the preoperative and postoperative values: 22.57 for the first. The results are recorded in the table in appendix n°… The values highlighted in pink are below the standard for the approach defined by the control group.

Ankle

For this joint, few patients have been analyzed, three authors have done so and there are: 34 preoperatively, 17 patients at 3 months and 12 months and 37 at 6 months. We can observe thanks to the study of Miki., *et al*. (2004) [11] that the ankle amplitude increases following the installation of the total hip prosthesis. This study concerns only the posterior approach. We calculated the variance of the results for only the study by Miki., *et al*. (2004) [11]: 3.14.

Walking parameter

We focused on the evolution of speed, cadence and stride length of patients studied preoperatively and over the months postoperatively. Overall, by comparing the preoperative data with the other analyzes, we can consider that these three spatiotemporal parameters improved at 1 year postoperatively. For some approaches some inconsistencies are observed. We will highlight them in the next paragraphs. We also calculated the variance of the different values obtained, to know the difference of the parameters over time.

Speed

Regarding speed: the control group, made up of 145 patients, experienced a minimum speed of 0.99 m/s. It was calculated for patients in the study by Agostini., *et al*. (2014) [1]. Bennett., *et al*. (2006) [3] recorded a walking speed for their group of 1.37 m/s. This value is the highest of the entire control group. For the lateral group, the speed was recorded in 38 patients preoperatively. It is between 1.02 m/s (Pospischill., *et al*. 2010 [14]) and 1.07 m/s (Queen., *et al*. 2013 [17]).

At 3 months, for the 20 patients of Pospischill., *et al*. (2010) [14], we observed a walking speed of 1.08 m/s. At 6 months no author has analyzed this spatiotemporal parameter. One year after the prosthesis break, the 20 patients of Varin., *et al*. (2013) [21] have a speed of 1.14 m/s and the 10 patients of Queen., *et al*. (2013) have a speed of 1.4 m/s (maximum speed all approaches combined).

Preoperatively, the anterior group is analyzed for speed for 78 patients. The minimum speed is 0.94 m/s for the study by Lugade., *et al*. (2010) [8]. The maximum speed is observed for the 11 patients of Rathod., *et al*. (2014) [18]. Its value is equal to 1.21 m/s. At 3 months, only Reininga., *et al*. (2013) [19] made recordings (1.2 m/s). At 6 months, Reininga., *et al*. (2013) [19] calculate a speed of 1.3 m/s while Rathod., *et al*. (2014) [17] show a slightly lower value, equivalent to 1.26 m/s. A year after the operation, these last authors show a value for the speed equal to 1.36 m/ s. The patients of the study by Varin., *et al*. (2013) [21] show an almost equal speed of 1.31 m/s.

For the posterior approach, the 17 patients in the study by Bennett., *et al*. (2006) [3] have a value for speed having no unit. We therefore chose not to take these results into account for our analysis, in order not to interfere with our results. The smallest value is represented by the study of Miki., *et al*. (2004) [11] with a speed equal to 0.85 m/s and the largest by Queen., *et al*. (2011) [16]: 1.14 m/s.

At 3 months only Miki., *et al*. chose to do analyzes: the speed is 1.02 m/s. At 6 months, the values are between 1.08 m/s for the patients of Miki., *et al*. And 1.31 m/s for the 10 patients of Nantel., *et al*. (2009) [12]. At 12 months postoperatively, Miki., *et al*. obtained a value of 1.05 m/s, Rathod., *et al*. (2014) 1.25 m/s and Queen., *et al*. (2013) obtain a value equal to 1.37 m/s. For this approach we find that the values at 12 months are lower than that at 6 months. 63 patients are analyzed preoperatively for the anterolateral approach. The speed values obtained for this approach are the highest. At 3 months, only Pospischill., *et al*. (2010) [14] gives a speed: 1.2 m/s. At 6 months Madsen., *et al*. (2004) [9] recorded a speed of 1.17 m/s. This value is slightly lower than the speed of the patients of Pospischill., *et al*. at 3 months. One year after the operation, Queen., *et al*. (2013) [17] showed a value of 1.4 m/s (maximum value recorded all approaches combined.) Concerning the posterolateral approach, 114 are examined. The patients of Zhou., *et al*. (2009) [20] have the lowest walking speed for all approaches: 0.44 m/s. At 3 and 6 months, improvements in walking speed are observed but at 12 months postoperatively the speed no longer improves.

Step pace

Next, let's move on to the pace of steps observed for the patients. This parameter is subject to many inconsistencies: for four approaches the number of steps/minutes postoperatively increases compared to preoperatively. The control group is made up of 76 patients for this parameter. Values range from 105.1 to 119 steps per minute. For the lateral approach, preoperatively only one author, Pospischill., *et al*. (2010) gives a value of 110 steps/minute. At 3 months this value remained the same. We observe a decrease in the number of steps at 12 months.

The pace for the anterior approach is 100 steps/minute (Reininga., *et al*. 2013). For this group an improvement in the pace is seen at 3 months postoperative (99.6 steps/minute) from 6 months the pace increases: 102.5 steps/min (Reininga., *et al*. 2013) and 112.1 steps/minute at 12 months (Varin., *et al*. 2013). The variance of Reininga., *et al*. (2013) is greater than 1, which means that the difference between the preoperative values, at 3, 6 and 12 months are notable. For the posterior approach, Bennett., *et al*. (2006) [3] do not inform us about the units of the parameter studied; We then did not include this data. The rate over the postoperative months increases from 110 steps/min preoperatively to 119 steps/minute. Miki., *et al*. (2004) has the highest variance rate in our study: there is a big difference between the pre and post-operative values.

Anterolateral, we observe preoperative analyzes, at 3 months and 6 months. 3 articles were studied: preoperatively Pospischill., *et al*. (2010) showed a pace of 107 steps/minute for the patients in his group. At 3 and 6 months the value of the cadence increases: Pospischill., *et al*. (2010) 109 steps/minute. And 114 steps/minute at 6 months Madsen., *et al*. (2004).

For the posterolateral approach, an improvement in pace is only visible between the 6th and 12th months. Preoperatively, Tanaka., *et al.* (2010) [20] 96.2 steps/min and Reininga., *et al*. (2013) [19] 100.4 steps/min. These values increase at 3 and 6 months to reach up to 115.2 steps/min Madsen., *et al*. (2004) [9]. Tanaka., *et al.* (2010) [20] recorded a rate of 104.4 steps/min at 12 months. Tanaka., *et al*. (2010) have a variance of 12.18, this article also has large differences between these pre- and post-operative values.

Step length

Four authors describe the stride length of their patients: this parameter is between 0.69m Bennett., *et al*. (2006) [3] and 0.95m Tanaka., *et al*. (2010) [19]. The lateral approach concerns 28 patients, the stride length is less than the healthy patient. We recorded up to 0.34m for the minimum value of our study (Queen., *et al*. (2011) [16]. In postoperative follow-up, we can conclude that the stride length improves markedly: 0.67m (Queen *et al*. 2014 [15]) to be equal to the value for the contralateral leg at 12 months. The previous approach concerns 47 patients, an improvement in the quality of the step is expected up to 6 months but no data is communicated to us 1 year after the implantation of the prosthesis.

The 46 patients of the posterior approach have a large value interval: 0.37m for Queen., *et al*. (2011) [16] up to 0.61m Queen., *et al*. (2013) [17]. Only Miki., *et al.* give us information at 3 and 6 months, the parameter does not improve at 6 months. At 12 months, the information is more representative because three authors give us their values.

The anterolateral approach has one author whose patients have the most affected stride length for our study: 0.34m for Queen., *et al*. (2011). For the postoperative follow-up we observe an improvement from 3 months but only one author is represented: Pospischill., *et al*. (2010) [14]. At 12 months Queen., *et al*. (2014 and 2011) showed a stride length equal to 0.67 m equivalent to the stride length of the healthy limb in patients. The posterolateral approach knows the study where the patient's stride length is the least affected: 0.94m Tanaka., *et al*. (2010) [20]. For each study, the parameter improves gradually up to 12 months.

Interpretations

Different factors contribute to the success of THA: the patient's physical form, his age, the factors of comorbidities, the surgical approach chosen… In this study we sought to set up a tool to allow the therapist a better view of all patients, having undergone a first THA for the kinematics and the spatio-temporal parameters of four joints of the lower limb. Each surgical approach has its advantages but also its disadvantages in relation to the various parameters such as: speed, risk of dislocation, weakness of the abductors: which is according to Queen., *et al*. (2013) [17] "the first cause of gait disturbances after such an intervention".

At 12 months postoperatively, we observe an improvement in all the parameters studied in this review of the literature, compared to the analysis carried out preoperatively. But we perceive that the sequelae due to the surgery will have consequences on the gait of patients from different groups. As Agostini., *et al*. (2014) [1] specify, "Muscle and periarticular damage is inevitable and leads to a loss of proprioceptors. We know that these sensors are necessary to enable the conscious orientation of the patient in space. They unconsciously inform the nervous system, allowing it to adjust muscle contractions but also to regulate posture and balance. For us, muscle weakness will be responsible for adapting the postoperative gait. Regular follow-up and specific rehabilitation for more than 3 months could help patients get as close as possible to healthy subjects.

Typically, after THA, patients show improved range of motion and better limb symmetry while walking. Complications are nevertheless to be expected because, as Madsen., *et al*. (2004) [9] explains to us, "surgical approaches affect different structures around the hip, which leads us to think that each group will have very distinct postoperative characteristics".

The surgical procedure is a factor that strongly influences the stability of the total hip replacement as well as the functioning of the abductors. The choice of approach will depend on the surgeon's preference, which is often influenced by his or her learning and personal experiences. A decrease in abductor strength is observed in surgical procedures where the gluteus medius will be detached (L.A., P.A. and A.L.)

Cinematic

Each joint shows us a functional improvement after the installation of the total hip replacement. The articular amplitudes of each of the joints approach the amplitudes observed for the control group without ever equaling them. In this paragraph, we highlight some values that may be of interest to analyze.

For the pelvis, we notice that the joint values improved 12 months postoperatively. For Miki., *et al*. (2004) [11] we notice that the pelvic obliquity values are positive and increase over time. The author shows that pelvic obliquity as well as pelvic tilt are correlated with hip amplitude. Abnormal pelvic obliquity can also be seen as an adaptation of pain or weakness in the abductors. Pelvic rotation at 12 months postoperatively is 11.3 ° and shows a strong improvement during the last 6 months of the analysis. This result is to be put in relation with the decrease in the amplitude of motion of the hip in the sagittal plane, indeed Miki., *et al*. (2004) [11] explains that a compensation occurs when the amplitude of the hip decreases, pelvic rotation increases. This is what we are seeing here.

Two authors [3,7] show very high values for hip ROM in the transverse plane compared to the results reported by Rathod., *et al*. (2014) [18]. It is difficult for us to explain these values because these studies only tell us about the preoperative results. Other analyzes were performed at 2 days, 6 and 16 weeks postoperatively, but we did not take these results into account. However, Bennett., *et al*. (2006) [3], state that preoperatively the patients in his study try to keep the affected hip in external rotation. We believe that this strategy is adopted with the intention of avoiding compression on the osteoarthritis or painful joint, in order to reduce the stress on the affected limb during ambulation, but it can also be due to a contraction of the external rotators of the body. hip, or compensation for a too long limb in the oscillating phase. Indeed, the external rotation of the hip logically leads to an out toeing walk. The opening of the step angle allows the patient's base of support to be widened and thus a better progression of the body forward. The results reported by Rathod., *et al*. (2014) improve but a deficit persists at 12 months. The author says the patients did not have specific hip rotator rehabilitation. This parameter could have helped patients regain strength and range of motion approaching standards.

We observe at 12 months postoperatively that for the range of motion of the hip in the sagittal plane, there is an asymmetry between the operated and healthy leg: when the hip is affected, the ROM values are lower than for a healthy hip [1,11,15]. Several authors attempt to explain these results. The first Lugade., *et al*. (2010) [8] believe that the asymmetries observed in the postoperative gait are probably due to compensatory behaviors and pain caused by osteoarthritis during ambulation. But this hypothesis seems implausible to us since the author does not do any analysis at 12 months. We can then think that improvements in kinematics are still possible between 6 and 12 months postoperatively. Then, Queen., *et al*. (2014) [15] hypothesize that patients end up with less range of motion in the sagittal plane for the operated hip, due to a lack of extension of the hip. joint. This amplitude limitation is undoubtedly due to the alteration following the surgery of the soft tissues, in particular of the joint capsule and of the muscle groups specific to the extension.

Regarding the range of motion of the knee in the sagittal plane, certain values should be highlighted. For three authors [1,3,11], these values are below the average recorded for the healthy control group. Each author goes there for his explanation. For Miki., *et al*. (2004) [11] the decrease in sagittal hip movement is correlated with the decrease in knee ROM in this same plane. This hypothesis is supported by a second author: Perron., *et al.* (2000) [13]. There would then be a compensation at the lumbar level through the pelvis which would aim to limit the sagittal movements of the hip. This is why some patients with hip osteoarthritis complain of pain in the lumbar region and see the development of osteoarthritis in these vertebrae. For Bennett., *et al*. (2006) [3] a completely different reason may explain these values. For him, the results do not return to normal because of muscle weakness and atrophies acquired over the years of osteoarthritis pain. This is because the decrease in knee flexion may be due to muscle weakness in the quadriceps. This muscle is present in certain surgical approaches (notably for P.A., A.A, and A.L.). These approaches are used by surgeons in the studies [3,11]. The reduction in knee flexion thus helps to avoid shear forces during joint mobility of the knee. And also, to reduce the compressive forces due to a contracted quadriceps.

Agostini., *et al*. (2014) [1] demonstrate an alteration in the range of motion of the hip and knee of the affected limb; this suggests that the limb is flexed more during the weight-bearing phase and then causes early activation of the anterior tibialis in order to prepare for the oscillating phase, where more ankle dorsiflexion will be needed to ensure adequate step passage.

The gait analysis made by the patients of Agostini., *et al*. (2014) [1] shows that "operated patients spend more time in heel contact", this will lead to an alteration of the ankle kinematics during the load. It then seems normal to obtain an ankle range of motion much greater than the values for healthy subjects. This assumption seems to agree with Beaulieu., *et al*. (2010) since it shows "a decrease in the propulsive phase and therefore an increase in heel contact".

The most damaged muscle group appears to be the hip rotators. In fact, for each surgical approach, the glutes are cut or removed. Weak abductors are likely to lead to lameness according to Queen., *et al.* (2013), pelvic tilt. According to Madsen., *et al*. (2004) [9] the medius and minimus gluteus are responsible for hip rotational movements essential for abduction and pelvic obliquity control during walking. Analyzes show that the patients most severely affected by the decrease in range of motion at 12 months are those who have undergone the anterolateral approach: the surgeon cuts out the FLT, the gluteus maximus and disinserts the gluteus medius and the vastus lateralis of the quadriceps. We thus agree with the hypothesis of Lugade., *et al*. (2010) [8] which assumed "that because of the trauma of the abductors, the anterolateral group will have more asymmetries in their postoperative steps. These asymmetries may be due to compensatory behaviors and pain caused by osteoarthritis while walking.

Spatio-temporal parameters

The results show a marked improvement in speed, stride length and cadence for each approach. Nevertheless, we observe for some authors some inconsistencies. Indeed Queen., *et al*. (2013) [17] calculate a very small step length of 0.34m for the lateral and anterolateral approach and of 0.37m for the posterior. We then focused on anthropological data to explain such differences compared to other studies. The 35 patients in the article are on average under the age of 60, and all have osteoarthritis, which is the case for the majority of patients studied here. The BMI of the 3 patient groups is quite high. We note a range of between 25.23 kg/m^2 for the posterior approach and up to 29.97 kg/m^2 for the anterolateral approach. The body mass index could then influence a patient's gait: by increasing the load on a defective joint, the patient is more likely to adopt compensatory behaviors in order to avoid pain when walking.

Conversely Tanaka., *et al*. (2010) [20] recorded a step length of 0.94m for these patients. Anthropological data show us that the BMI of the patients is 24.64 kg/m^2. As this value is lower than the mean BMI of the control group, it could have a link between the patient's stride length and their BMI; The lower the body mass index, the longer the stride length is likely to be.

Reininga., *et al*. (2013) [19] show an increase in the pace of steps at 6 months. This means that patients shorten their pace in order to spend more time in the bipodal station. Anthropological data do not give us any data that could explain such a result. In general, rehabilitation for patients who have had THA takes about 3 months. We therefore believe that the rehabilitation of patients who have undergone THA should be continued after the 3 months postoperatively, with the aim of improving the parameters studied. Two other authors show a high rate: Madsen., *et al*. (2004) [9] and Miki., *et al*. (2004) [11]. These high values can be explained by the fact that the patients had an indication of PTH because of pathologies more rapidly destructive than osteoarthritis (necrosis, dysplasia, etc.). The joints were much more damaged, the rehabilitation time and the consequences on the patients' gait will be more important.

This study has some limitations which may influence the results analyzed. First, not all studies have preoperative data. Analyzes done before surgery are important because they can be used to assess the presence of analgesic gait, Trendelenburg lameness or unequal length of the lower limb. Such information may explain postoperative results that would be below the standards obtained for the control group sample.

Then surgical procedures are performed by many surgeons. We know that the choice of approach is dependent on the surgeon's preferences and experience. There is then an influence on the execution of the procedure, to guarantee a perfect recovery to the patient.

Conclusion

The total hip prosthesis is in our opinion a good way to restore adequate joint mobility, our results show a clear improvement in kinematics and spatiotemporal parameters, but the results of the operated patients remain below the values of the control group for 12 months. after the operation.

Through this work, we sought to explain to practitioners what the influences of total hip prosthesis may be when walking. This analysis of the literature allowed us to highlight some parameters that could influence the postoperative approach. The main parameter being the surgical approach chosen by the surgeon: this will be decisive for the kinematic or spatiotemporal values because different muscle structures will be affected. Proper rehabilitation of the muscle group affected during the procedure makes it possible to achieve an ambulation closer to healthy subjects. However, several parameters were not studied during this analysis.

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