Journal of Health Care and Research
(ISSN: 2582-8967)
Review Article
DOI: https://doi.org/10.36502/2022/hcr.6204

Robotic Surgery in Total Hip Replacement in Obesity

Mohammed Almashahedi[1*], Wasim Khan[2], Stephen McDonnell[2]
[1]Arthroplasty Fellow, Addenbrooke's National Health Service Hospital, Cambridge University, United Kingdom
[2]Associate Professor, Trauma and Orthopaedic Consultant, Addenbrooke's National Health Service Hospital, Cambridge University, United Kingdom

Corresponding Author: **Mohammed Almashahedi** ORCID iD
Address: Arthroplasty Fellow, Addenbrooke's National Health Service Hospital, Cambridge University, United Kingdom; E-Mail: muhammedhaitham55@gmail.com
Received date: 20 December 2021; **Accepted date**: 28 January 2022; **Published date**: 10 February 2022

Citation: Almashahedi M, Khan W, McDonnell S. Robotic Surgery in Total Hip Replacement in Obesity. J Health Care and Research. 2022 Feb 10;3(1):1-6.

Abstract

Total hip replacement is one of the most successful orthopaedic operation of recent time. The outcomes of THR may be influenced by several factors including patient demographics, surgical technique and implant features. One of the most important surgeon-controlled factors is component positioning. Surgical positioning of the acetabular cup and femoral prosthesis remains fundamental to obtaining accurate implant fit and prevent hip dislocation or impingement. Different categories of robotic assistance have been established during the previous years and all of the technologies target accuracy and reliability to reduce complications, and enhance clinical outcomes.

In this article we discuss the advantages and difficulties of robotic total hip replacement in obese patient and provide the recent scientific evidence from the literatures.

Keywords

Robotic Surgery, Hip Replacement, Obesity, Orthopaedic Operation

Introduction

THR is one of the most successful and common surgical procedures. THR replaces the damaged femoral head and the acetabulum with the prosthesis with a total of 98,211 THRs performed in England and Wales in 2015 [1]. The number of THR is still rising. Australian figures predict a 219% increase in primary THR from 2013 to 2046 [2]. These occur due to an increase in the incidence of osteoarthritis and other degenerative diseases affecting the bone and joints [3].

Obesity is a primary modifiable risk factor for the development of [4]. The World Health Organization defines obesity as a BMI ≥ 30 [5]. Increase in the joint reaction force and altered biomechanics create abnormal impact loading and altered gait. Increased accumulation of body fat and adipokines contributing to low-grade systemic inflammation which negatively affects cartilage biology [6]. Obesity is significantly associated with a greater need for joint arthroplasty compared to age-matched controls [7] and surprisingly and studies have shown that patients with a high body mass index (BMI) may require a hip replacement up to ten years earlier than patients with a normal BMI [8]. The surgical management of obese patients is challenging, from theatres, operating tables and beds, surgical exposure and post-operative rehabilitation.

Robotic-assisted THR, first introduced in the 1990s, provides accurate and reproducible component positioning and balancing of soft tissue [9]. These benefits may contribute to longer implant survival and a decrease need for revision surgery [10]. The implants insertion appears to be one of the fundamental factors for implant survival. Poor positioning was correlated to a higher rate of intra-prosthetic or periprosthetic dislocation [9]. In addition, impingement, pain, leg length discrepancy, accelerated implant wear, loosening [11] poor functional outcomes, and increased surgical revision rates were also correlated to poor implant positioning. Long-term outcomes and survivorship of THR are dependent on the accurate restoration of hip biomechanics, which is achieved through optimal component positioning [12]. It is evident that suboptimal component positioning leads to joint instability, increased wear and poor function [13]. There are 3 robots in orthopaedic passive, active (autonomous) and semi-active (haptic). The latter two are commonly used.

In passive robotic systems, the surgeon retains control of the robot throughout the procedure. While in the semi active systems require the surgeon to guide the robotic arm for bony preparation via a haptic feedback mechanism that ensures minimal deviation from the pre-determined surgical plan and it is a common robotic system used now [14,15]. The robot was programmed using pre-operative computed tomography (CT) to carry out bony preparation for component implantation once adequate surgical exposure was achieved intra-operatively.

The longer-term outcomes in obese patients following primary robotic THR is unclear, with some studies reporting similar outcomes to patients with a normal BMI [16-18], and some reporting inferior outcome [19]. Perets et al. looked at patient satisfaction at a minimum of two-year follow-up [20]. For the robotic Total Hip cases considered in this study, mean patient satisfaction was a high 9.3 out of 10 [20].

Advantage of Robotic Surgery

Callanan et al. reported on acetabular cup positioning performed by several experienced surgeons during a 5-year period, using the conventional THR technique, they reported 47% of cups were in their modified safe zone. Their results were superior using the conventional (62%) and robotic techniques (92%) in placing the cup in their modified safe zone in obese patients [21].

Callanan et al. suggested a modified safe zone with inclination of 30 to 45 degrees and anteversion of 5 to 25 degrees [21]. They suggested a lower upper limit of inclination 45 degrees instead of 50 degrees suggested by Lewinnek et al. based on the study by Leslie et al. [22] that showed increased wear and edge loading in THRs with a hard-on-hard bearing surface with an abduction angle greater than 45 degrees.

Suarez-Ahedo et al. studied bone preservation during acetabular reaming in primary THR and performed a matched pair control study which demonstrated that when compared to conventional THR (n=57), robotic-arm assisted THR (n=57) allowed for more precise reaming [23]. This led to the use of smaller acetabular cups in relation to the patient's femoral head size. Using acetabular bone resection, these results suggested greater preservation of bone stock using robotic-arm assisted THR compared to conventional THR [23].

The Importance of the Learning Curve

According to surgical team learning curve, Redmond et al. researched the learning curve during the adoption of robotic-arm assisted THR as measured by component position, operative time and complications [24]. The robot provides a single-ream option, eliminating the need for the surgeon to perform multiple reams to achieve final ream size, for this, performing reaming and cup insertion may enhance the ergonomic health and reduce the workload demand on the surgeon [25].

Surgeons who performed robotic THRs demonstrated reduced caloric expenditure during acetabular reaming and acetabular implantation [26]. With the robotic system assisting through use of a stereotactic boundary, the surgeons also reported less physical and mental demand during acetabular reaming and acetabular implantation, with statistically significantly less mental demand during acetabular reaming in robotic THR group [27].

The authors reported a decreased risk of acetabular component malpositioning with robot experience [24]. A learning curve of 35 cases was observed, as a decreased incidence of acetabular component outliers and decreased operative times were noted with increased surgical experience with the robot [24].

Length of Stay

When exploring a patient's road to recovery, their length of stay in hospital after surgery is a key factor to consider. Heng et al. retrospectively compared the length of stay of 45 patients who underwent robotic THRs against those who received conventional THR [28]. They reported similar results in both groups, however once the patients who required inpatient rehabilitation were excluded, the robotic group had a shorter hospital stay (4.22 days vs. 5.93) [28]. This finding was further validated by another study conducted by Banchetti et al., who retrospectively analyzed 107 patients at 24-months follow-up (robotic THR, n= 56; conventional THR, n=51) [29].

Overall, early data from these studies suggests that obese patients who undergo robotic THR may be able, on average, to go back home sooner after surgery than those who undergo conventional THR. This may give a great advantage for the patients well-being and offer financial benefits to healthcare institutions, since a reduction in length of hospitalization has the potential to reduce economic burden to hospitals [29]. In addition, these findings have the potential to offer financial benefits to healthcare institutions since a reduction in the length of stay post-robotic THR surgery potentially reduces the economic burden to hospitals. This is a key area being investigated by various surgeons worldwide.

Cost Effectiveness

In assessing the potential effects of robotic THR on costs to private payers and Medicare, Maldonado and colleagues created a Markov model to compare the costs of robotic THR and conventional THR [25]. The model considered the cost of postoperative events such as infection, dislocation and revisions [25]. Using clinical data from 555 patients and comparing it with literature, the model simulated the outcomes and cumulative costs over five years [25]. Cost estimates were taken from the Medicare Standard Analytical Files and a modifier was used to estimate private payer costs [25]. The model showed that robotic THR was cost effective compared to conventional THR for Medicare ($14,228 vs. $15,313) and private pay ($23,816 vs. $25,633) [25].

Further benefits include intra-operative calculations of hip length, offset and combined version, and the ability to make the relevant component adjustments accordingly. All of these are difficult to achieve in conventional THR in obese patients [30]. The robotic system increased the cost compared to conventional THR [31]. Positioning of the acetabular cup in obese patients may be more challenging [32], In addition, malposition of the acetabular component is a prime cause of [33] hip instability, which is the most common cause for revision in the United States [34].

Operative Time

Kong et al. published a retrospective comparative cohort study of a professional manual surgeon's first 100 robotic-assisted THRs compared to the surgeon's last 100 manual cases [35]. The average operating time of robotic assisted THR was 95.92 ± 15.64 minutes, ranging from 68 to 145 minutes [35]. The learning curve was assessed using a cumulative summation test for learning curve analysis which demonstrated that after the 14th case, a downtrend in the surgeon's operative time began [35]. There was no statistical difference between the first 14 cases versus cases 15 to 100 when considering cup positioning, postoperative LLD, offset and Harris hip score (HHS) [35]. Results indicate that there was a 14-case learning curve when considering operative time; however, the authors noticed that this learning curve did not impact patient outcomes [35].

Heng et al. carried out a retrospective comparison of a single surgeon's last 45 conventional THRs performed prior to changing to the robotic-arm assisted system, and compared them with the first 45 robotic-arm assisted THRs [36]. When comparing surgical times between the two groups, they found that the average surgical time was 96.7 minutes for the robotic-arm assisted group and 84.9 minutes for conventional group [36]. Upon further analysis, the authors determined that each robotic arm assisted operation was approximately one minute shorter than the previous robotic operation and the average time for the last 10 cases was reduced to 82.9 minutes, which was quicker than the average time of the conventional group. It was concluded that surgical time is comparable with conventional techniques after the initial learning curve of approximately 35 cases [36].

The surgical time in operating an obese patient is longer due to preoperative preparation and longer time for surgical exposure. In addition, the robot needs time for setup and draping, so all these factors add up. Furthermore, the difficulty in reaming the acetabulum in obese patients and placing the final cup can also be challenging for the surgeons.

Conclusion

This study has some limitations, mainly due to the low level of evidence of the papers available on this topic which did not provide clear guidelines, however, this could represent a helpful starting point from which to address further research on this relevant topic.

The robotic THR in obese patients is challenging and can be associated with complications including a cost of the robot, the presence of an engineer during the surgery, blood loss, long operation time and difficulty in positioning the acetabular cup. In the other hand, the precise acetabular cup position and with soft tissue balance, are major advantages in the use of robot in THR. We need further studies and researches with long term follow up to understand topic correctly.

References

[1] National Joint Registry. 13th annual report 2016: National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. United Kingdom: National Joint Registry; 2016 [cited 2018 Aug 16]. Available from: https://www.njrcentre.org.uk/njrcentre/Portals/0/Documents/England/Reports/13th%20Annual%20Report/07950%20NJR%20Annual%20Report%202016%20ONLINE%20REPORT.pdf

[2] Inacio MCS, Graves SE, Pratt NL, Roughead EE, Nemes S. Increase in Total Joint Arthroplasty Projected from 2014 to 2046 in Australia: A Conservative Local Model With International Implications. Clin Orthop Relat Res. 2017 Aug;475(8):2130-37. [**PMID**: 28488253]

[3] Johnson VL, Hunter DJ. The epidemiology of osteoarthritis. Best Pract Res Clin Rheumatol. 2014 Feb;28(1):5-15. [**PMID**: 24792942]

[4] Marks R, Allegrante JP. Body mass indices in patients with disabling hip osteoarthritis. Arthritis Res. 2002;4(2):112-16. [**PMID**: 11879546]

[5] Arden NK, Kiran A, Judge A, Biant LC, Javaid MK, Murray DW, Carr AJ, Cooper C, Field RE. What is a good patient reported outcome after total hip replacement? Osteoarthritis Cartilage. 2011 Feb;19(2):155-62. [**PMID**: 20951814]

[6] Guilak F. Biomechanical factors in osteoarthritis. Best Pract Res Clin Rheumatol. 2011 Dec;25(6):815-23. [**PMID**: 22265263]

[7] Harms S, Larson R, Sahmoun AE, Beal JR. Obesity increases the likelihood of total joint replacement surgery among younger adults. Int Orthop. 2007 Feb;31(1):23-26. [**PMID**: 16688455]

[8] Haynes J, Nam D, Barrack RL. Obesity in total hip arthroplasty: does it make a difference? Bone Joint J. 2017 Jan;99-B (1 Supple A):31-36. [**PMID**: 28042116]

[9] Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am. 1978 Mar;60(2):217-20. [**PMID**: 641088]

[10] Lang JE, Mannava S, Floyd AJ, Goddard MS, Smith BP, Mofidi A, Seyler TM, Jinnah RH. Robotic systems in orthopaedic surgery. J Bone Joint Surg Br. 2011 Oct;93(10):1296-99. Erratum in: J Bone Joint Surg Br. 2011 Dec;93(12):1679. [**PMID**: 21969424]

[11] Yoder SA, Brand RA, Pedersen DR, O'Gorman TW. Total hip acetabular component position affects component loosening rates. Clin Orthop Relat Res. 1988 Mar;(228):79-87. [**PMID**: 3342591]

[12] Bukowski BR, Anderson P, Khlopas A, Chughtai M, Mont MA, Illgen RL 2nd. Improved Functional Outcomes with Robotic Compared with Manual Total

Hip Arthroplasty. Surg Technol Int. 2016 Oct 26;29:303-308. [**PMID**: 27728953]

[13] Cassidy KA, Noticewala MS, Macaulay W, Lee JH, Geller JA. Effect of femoral offset on pain and function after total hip arthroplasty. J Arthroplasty. 2012 Dec;27(10):1863-69. [**PMID**: 22810007]

[14] Kayani B, Konan S, Ayuob A, Ayyad S, Haddad FS. The current role of robotics in total hip arthroplasty. EFORT Open Rev. 2019 Nov 1;4(11):618-25. [**PMID**: 31754468]

[15] Perets I, Mu BH, Mont MA, Rivkin G, Kandel L, Domb BG. Current topics in robotic-assisted total hip arthroplasty: a review. Hip Int. 2020 Mar;30(2):118-24. [**PMID**: 31868012]

[16] Lowe GD, Haverkate F, Thompson SG, Turner RM, Bertina RM, Turpie AG, Mannucci PM. Prediction of deep vein thrombosis after elective hip replacement surgery by preoperative clinical and haemostatic variables: the ECAT DVT Study. European Concerted Action on Thrombosis. Thromb Haemost. 1999 Jun;81(6):879-86. [**PMID**: 10404761]

[17] Haverkamp D, Klinkenbijl MN, Somford MP, Albers GH, van der Vis HM. Obesity in total hip arthroplasty--does it really matter? A meta-analysis. Acta Orthop. 2011 Aug;82(4):417-22. [**PMID**: 21657972]

[18] Lehman DE, Capello WN, Feinberg JR. Total hip arthroplasty without cement in obese patients. A minimum two-year clinical and radiographic follow-up study. J Bone Joint Surg Am. 1994 Jun;76(6):854-62. [**PMID**: 8200892]

[19] Jackson MP, Sexton SA, Yeung E, Walter WL, Walter WK, Zicat BA. The effect of obesity on the mid-term survival and clinical outcome of cementless total hip replacement. J Bone Joint Surg Br. 2009 Oct;91(10):1296-300. [**PMID**: 19794162]

[20] Perets I, Walsh JP, Close MR, Mu BH, Yuen LC, Domb BG. Robot-assisted total hip arthroplasty: Clinical outcomes and complication rate. Int J Med Robot. 2018 Aug;14(4):e1912. [**PMID**: 29761618]

[21] Callanan MC, Jarrett B, Bragdon CR, Zurakowski D, Rubash HE, Freiberg AA, Malchau H. The John Charnley Award: risk factors for cup malpositioning: quality improvement through a joint registry at a tertiary hospital. Clin Orthop Relat Res. 2011 Feb;469(2):319-29. [**PMID**: 20717858]

[22] Leslie IJ, Williams S, Isaac G, Ingham E, Fisher J. High cup angle and microseparation increase the wear of hip surface replacements. Clin Orthop Relat Res. 2009 Sep;467(9):2259-65. [**PMID**: 19363640]

[23] Suarez-Ahedo C, Gui C, Martin TJ, Chandrasekaran S, Lodhia P, Domb BG. Robotic-arm assisted total hip arthroplasty results in smaller acetabular cup size in relation to the femoral head size: a matched-pair controlled study. Hip Int. 2017 Mar 31;27(2):147-52. [**PMID**: 28362049]

[24] Redmond JM, Gupta A, Hammarstedt JE, Petrakos AE, Finch NA, Domb BG. The learning curve associated with robotic-assisted total hip arthroplasty. J Arthroplasty. 2015 Jan;30(1):50-54. [**PMID**: 25262438]

[25] Maldonado DR, Go CC, Kyin C, Rosinsky PJ, Shapira J, Lall AC, Domb BG. Robotic Arm-assisted Total Hip Arthroplasty is More Cost-Effective Than Manual Total Hip Arthroplasty: A Markov Model Analysis. J Am Acad Orthop Surg. 2021 Feb 15;29(4):e168-77. [**PMID**: 32694323]

[26] Abbruzzese K, Byrd Z, Smith R, Valentino A, Yanoso-Scholl L, Harrington MA, Parsley B. Assessment of Surgeon Biometrics During Manual and Robotic-Assisted Total Hip Arthroplasty. In Orthopaedic Proceedings 2020 Feb (Vol. 102, No. SUPP_1, pp. 101-101). The British Editorial Society of Bone & Joint Surgery.

[27] Valentino A, Scholl L, Hampp EL, Smith R, Byrd Z, Mont M. Physical and mental demand during total hip arthroplasty. Presented at: Orthopaedic Research Society (ORS) Annual Meeting; February 8-11, 2020; Phoenix, AZ.

[28] Heng YY, Gunaratne R, Ironside C, Taheri A. Conventional vs robotic-arm assisted total hip arthroplasty (THA) surgical time, transfusion rates, length of stay, complications and learning curve. J Arthritis. 2018;7(4):1.

[29] Banchetti R, Dari S, Ricciarini ME, Lup D, Carpinteri F, Catani F, Caldora P. Comparison of conventional versus robotic-assisted total hip arthroplasty using the mako system: An Italian retrospective study. J Health and Soc Sci. 2018;3(1):37-48.

[30] Siebel T, Käfer W. Klinisches outcome nach roboter-assistierter versus konventionell implantierter hüftendoprothetik: Prospektive, kontrollierte untersuchung von 71 patienten. Z Orthop Ihre Grenzgeb. 2005;143:391–98.

[31] Chen KK, Kim KY, Vigdorchik JM, Meere PA, Bosco JA, Iorio R. Costeffectiveness analysis of robotic arthroplasty. In: Lonner JH, ed. Robotics in knee and hip arthroplasty. Switzerland: Springer International Publishing; 2019. 67–74.

[32] Gupta A, Redmond JM, Hammarstedt JE, Petrakos AE, Vemula SP, Domb BG. Does Robotic-Assisted Computer Navigation Affect Acetabular Cup Positioning in Total Hip Arthroplasty in the Obese Patient? A Comparison Study. J Arthroplasty. 2015 Dec;30(12):2204-207. [**PMID**: 26253480]

[33] Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. J Arthroplasty. 2002 Apr;17(3):282-88. [**PMID**: 11938502]

[34] Sculco PK, Austin MS, Lavernia CJ, Rosenberg AG, Sierra RJ. Preventing Leg Length Discrepancy and Instability After Total Hip Arthroplasty. Instr Course Lect. 2016;65:225-41. [**PMID**: 27049193]

[35] Kong X, Yang M, Jerabek S, Zhang G, Chen J, Chai W. A retrospective study comparing a single surgeon's experience on manual versus robot-assisted total hip arthroplasty after the learning curve of the latter procedure - A cohort study. Int J Surg. 2020 May;77:174-80. [**PMID**: 32259592]

[36] Heng YY, Gunaratne R, Ironside C, Taheri A. Conventional vs robotic-arm assisted total hip arthroplasty (THA) surgical time, transfusion rates, length of stay, complications and learning curve. J Arthritis. 2018;7(4):1.