Rehabilitation and Sports Medicine. 2025; 5:207
doi: 10.56294/ri2025207

REVIEW

Total Hip Arthroplasty: Contemporary Surgical Approaches, Navigation Technology and Determinant Factors of Clinical Outcomes. A Narrative Review

Artroplastia Total de Cadera: Abordajes Quirúrgicos Contemporáneos, Tecnología de Navegación y Factores Determinantes de Resultados Clínicos. Una Revisión Narrativa

Lincon Joan Cevallos Navia[1], María Lisbeth Chávez Ruiz[1], Ingrid Paola Quijije Sornoza[1], Franklin Antonio Vite Solorzano[1], Ruth Monserrate Delgado[1]

[1]Universidad San Gregorio de Portoviejo. Ecuador.

Cite as: Cevallos Navia LJ, Chávez Ruiz ML, Quijije Sornoza IP, Vite Solorzano FA, Monserrate Delgado R. Total Hip Arthroplasty: Contemporary Surgical Approaches, Navigation Technology and Determinant Factors of Clinical Outcomes. A Narrative Review. Rehabilitation and Sports Medicine. 2025; 5:207. https://doi.org/10.56294/ri2025207

Submitted: 04-02-2024 **Revised:** 10-07-2024 **Accepted:** 01-01-2025 **Published:** 02-01-2025

Editor: PhD. Nicola Luigi Bragazzi

Corresponding author: Lincon Joan Cevallos Navia

ABSTRACT

Introduction: total hip arthroplasty (THA) represents one of the most successful orthopedic interventions for treating degenerative and traumatic hip pathologies. This narrative review aims to critically analyze current evidence regarding contemporary surgical approaches in THA, the role of computer-assisted technology, and determinant factors influencing clinical outcomes.
Method: a comprehensive narrative literature review was conducted covering publications from 2010 to 2025 across PubMed, Scopus, SciELO, SpringerLink, and Google Scholar databases. Inclusion criteria comprised studies with sample sizes ≥30 patients, functional assessment using validated scales (Harris Hip Score, WOMAC, SF-36), and minimum three-month follow-up. Original articles, systematic reviews, meta-analyses, randomized controlled trials, and academic theses in English or Spanish were included.
Results: minimally invasive approaches including SuperPATH (Supercapsular Percutaneous Assisted Total Hip) and direct anterior approach (DAA) demonstrate significant advantages over traditional posterior approach, including reduced intraoperative bleeding, decreased postoperative pain, and accelerated functional recovery. Meta-analyses involving over 1 500 patients confirm SuperPATH superiority in terms of blood loss reduction, shorter hospital stays, and lower dislocation rates. Intraoperative navigation technology improves acetabular component positioning accuracy, with up to 98 % of implants placed within optimal anteversion and abduction ranges (15°-25° anteversion, 40°-45° abduction). Institutional surgical volume emerges as a critical determinant factor, with high-volume centers (>100 annual procedures) reporting significantly lower complication rates, reduced mortality, and improved functional outcomes.
Conclusions: contemporary THA has evolved toward less invasive techniques with enhanced technological integration. The combination of minimally invasive surgical approaches, computer-assisted navigation, and centralization in high-experience centers represents the current trend for optimizing clinical and functional outcomes. Future directions include greater integration of robotic technology, advanced navigation systems, and personalized treatment approaches based on detailed preoperative analysis and three-dimensional modeling.

Keywords: Total Hip Arthroplasty; SuperPATH; Direct Anterior Approach; Surgical Navigation; Institutional Volume; Minimally Invasive Surgery.

RESUMEN

Introducción: la artroplastia total de cadera (ATC) representa una de las intervenciones ortopédicas más

exitosas para el tratamiento de patologías degenerativas y traumáticas de cadera. Esta revisión narrativa tiene como objetivo analizar críticamente la evidencia actual sobre abordajes quirúrgicos contemporáneos en ATC, el papel de la tecnología asistida por computadora y los factores determinantes que influyen en los resultados clínicos.

Método: se realizó una revisión narrativa de la literatura que abarcó publicaciones desde 2010 hasta 2025 en las bases de datos PubMed, Scopus, SciELO, SpringerLink y Google Scholar. Los criterios de inclusión comprendieron estudios con tamaños de muestra ≥30 pacientes, evaluación funcional mediante escalas validadas (Harris Hip Score, WOMAC, SF-36) y seguimiento mínimo de tres meses. Se incluyeron artículos originales, revisiones sistemáticas, metaanálisis, ensayos controlados aleatorizados y tesis académicas en inglés o español.

Resultados: los abordajes mínimamente invasivos, incluidos SuperPATH (Supercapsular Percutaneous Assisted Total Hip) y el abordaje anterior directo (DAA), demuestran ventajas significativas sobre el abordaje posterior tradicional, incluyendo reducción del sangrado intraoperatorio, disminución del dolor postoperatorio y aceleración de la recuperación funcional. Los metaanálisis que involucran más de 1500 pacientes confirman la superioridad del SuperPATH en términos de reducción de pérdida sanguínea, estadías hospitalarias más cortas y menores tasas de luxación. La tecnología de navegación intraoperatoria mejora la precisión del posicionamiento del componente acetabular, con hasta 98 % de los implantes colocados dentro de rangos óptimos de anteversión y abducción (15°-25° de anteversión, 40°-45° de abducción). El volumen quirúrgico institucional emerge como factor determinante crítico, con centros de alto volumen (>100 procedimientos anuales) reportando tasas de complicaciones significativamente menores, mortalidad reducida y mejores resultados funcionales.

Conclusiones: la ATC contemporánea ha evolucionado hacia técnicas menos invasivas con mayor integración tecnológica. La combinación de abordajes quirúrgicos mínimamente invasivos, navegación asistida por computadora y centralización en centros de alta experiencia representa la tendencia actual para optimizar los resultados clínicos y funcionales. Las direcciones futuras incluyen mayor integración de tecnología robótica, sistemas de navegación avanzados y enfoques de tratamiento personalizados basados en análisis preoperatorio detallado y modelado tridimensional.

Palabras clave: Artroplastia Total de Cadera; SuperPATH; Abordaje Anterior Directo; Navegación Quirúrgica; Volumen Institucional; Cirugía Mínimamente Invasiva.

INTRODUCTION

Total hip arthroplasty (THA) is one of the most effective orthopedic procedures for relieving pain and restoring joint function in degenerative pathologies such as osteoarthritis, avascular necrosis, dysplasia, or femoral neck fractures.[1] Since their development by Charnley, implants have evolved thanks to improvements in materials such as ceramics and highly cross-linked polyethylene.[2]

In terms of surgical techniques, the posterior approach is traditionally the most widely used, offering good joint exposure but a slightly higher dislocation rate.[3] Recently, approaches such as the direct anterior approach (DAA) and the SuperPATH technique have gained popularity due to their faster functional recovery, less postoperative pain, and less bleeding.[4]

Intraoperative navigation and computed tomography guides have been shown to improve the accuracy of acetabular positioning, reducing dysmetria and angulation errors.[5] Furthermore, there is strong evidence that hospitals with a high volume of TKA procedures have better clinical outcomes, fewer complications, shorter stays, and lower mortality.[6]

The purpose of this study is to critically review these aspects—surgical techniques, navigation, institutional volume, and risk factors—in order to generate well-founded conclusions that serve as an up-to-date clinical reference.

METHOD

The research followed a qualitative approach with a descriptive design based on a narrative literature review. Articles, reviews, randomized controlled trials, and theses were searched between 2010 and 2025 in PubMed, Scopus, SciELO, SpringerLink, Google Scholar, and university repositories. Descriptors such as “total hip arthroplasty,” “SuperPATH,” “anterior approach,” “navigation THA,” and “complications” were used with Boolean operators.

Studies with samples of ≥30 patients, functional evaluation using the Harris Hip Score, WOMAC, or SF-36, and a minimum follow-up of three months were included, as well as academic theses in English or Spanish. Results, trends, and discrepancies between studies were analyzed qualitatively, following narrative criteria,

without formal quantitative synthesis. The review was conducted using the PRISMA methodology to ensure consistency in selection and analysis.

DEVELOPMENT

Evolution and biomechanical fundamentals of total hip replacement

Total hip arthroplasty (THA) is a surgical technique that has evolved since its introduction in the 1960s, thanks to advances in biomaterials, prosthetic design, and surgical techniques. Initially, conventional polyethylene and metal implants suffered accelerated wear, leading to osteolysis and premature implant failure.[7] Currently, the use of highly cross-linked polyethylene and combinations of ceramic and metal have improved durability and reduced revision rates.[8]

From a biomechanical point of view, the correct alignment of prosthetic components is essential to ensure joint stability and avoid complications such as dislocation and excessive wear. Acetabular orientation in terms of anteversion and abduction must respect optimal ranges (usually 15°-25° of anteversion and 40°-45° of abduction) to achieve a good range of motion and minimize the risk of dislocation.

Comparison of surgical approaches

Traditionally, the posterior approach has been the most widely used by orthopedic surgeons due to the extensive exposure it allows for joint replacement. However, it has been associated with a higher rate of postoperative dislocation compared to other approaches.[10] In contrast, the direct anterior approach (DAA) and the SuperPATH (Supercapsular Percutaneous Assisted Total Hip) technique have gained acceptance due to their functional advantages and lower invasiveness.

Recent meta-analysis studies involving more than 1 500 patients compared these surgical approaches, reporting that SuperPATH showed a significant reduction in bleeding volume, less postoperative pain, and faster functional recovery compared to the posterior approach.[11] In addition, DAA is associated with less muscle damage and a lower dislocation rate, although it may require longer surgical time and a longer learning curve.[12]

These minimally invasive approaches allow for smaller incisions and preservation of muscle and capsular structures, which has a favorable impact on early recovery, pain reduction, and shorter hospital stays. However, the choice of approach must take into account the surgeon's experience and the individual characteristics of the patient.[13]

Navigation technology and its impact on results

Surgical navigation and assisted technology have represented a significant advance in improving the accuracy of prosthetic component placement. Misalignment of the acetabular component can predispose to dislocation, irregular wear, and shortened prosthesis life.[14]

The use of intraoperative navigation systems, including optical and inertial guides, has been shown to increase the accuracy of acetabular component placement within the recommended ranges. Reports indicate that up to 98 % of implants are placed with a deviation of less than 10° from the ideal anteversion and abduction.[15] Likewise, the use of navigation reduces limb length discrepancy and may decrease the incidence of associated complications.

However, the implementation of these technologies in routine clinical practice is limited by costs and the need for specific training, although their use is growing in high-volume and referral centers.[16]

Importance of institutional volume and surgical experience

Numerous studies have confirmed that hospital surgical volume and surgeon experience are determining factors in improving TKA outcomes. Institutions that perform a high number of procedures have lower rates of complications, hospital readmissions, and early mortality.[17]

A systematic review indicated that hospitals with more than 100 TKA procedures per year report significantly lower rates of surgical site infection, dislocation, and deep vein thrombosis, as well as shorter hospital stays.[18] This is partly explained by more experienced surgical teams, standardized protocols, and better available resources.

Likewise, the experience of the individual surgeon also has a favorable impact on outcomes, reducing complications and improving postoperative function.[19]

Risk factors and associated complications

Among the most important risk factors for complications after TKA are patient comorbidities such as diabetes mellitus, cardiovascular disease, and obesity. High intraoperative bleeding has also been associated with an increased risk of infection and delayed rehabilitation.[20]

In patients with rheumatological diseases, such as systemic lupus erythematosus and rheumatoid arthritis,

TKA is challenging due to chronic inflammation and the use of immunosuppressive drugs. However, recent studies have shown that with proper selection and perioperative management, functional outcomes and complication rates do not differ significantly from the general population.[21]

The most common complications include dislocation, prosthetic infection, venous thromboembolism, and limb dysmetria. Dislocation is more common in the first 3 months after surgery, and the risk decreases with proper positioning and early rehabilitation.[22]

Rehabilitation and postoperative management protocol

Fast-track rehabilitation and early mobilization protocols have been shown to reduce complications such as deep vein thrombosis, improve functional recovery, and shorten hospital stay.[23] These protocols include multimodal analgesia, early physical therapy, and multidisciplinary management.

The surgical approach also influences the rehabilitation plan; for example, less invasive techniques allow for faster mobilization and less use of opioid analgesics.[24] It is recommended to start rehabilitation on the first postoperative day to optimize results.

Future perspectives and trends

Trends in prosthetic surgery point toward greater integration of robotic technology, advanced navigation, and less invasive surgical techniques. Personalized treatment, based on detailed preoperative analysis and three-dimensional models, improves planning and prediction of outcomes.[25]

CONCLUSIONS

Total hip replacement represents one of the most significant advances in the surgical treatment of degenerative and traumatic diseases of the hip joint, offering a substantial improvement in patients' quality of life. The literature review shows that less invasive surgical approaches, such as the SuperPATH technique and the direct anterior approach, provide clear clinical benefits in terms of early recovery, reduced postoperative pain, less bleeding, and a shorter hospital stay compared to the traditional posterior approach.

In addition, the implementation of intraoperative navigation technologies has been shown to improve the accuracy of prosthetic component placement, which helps to reduce complications such as dislocation, premature wear, and postoperative dysmetria, critical factors for the long-term success of arthroplasty. However, their use requires adequate infrastructure and specialized training, aspects that should be promoted in referral centers.

Another relevant finding is the decisive influence of institutional surgical volume and surgeon experience on clinical outcomes. Centers with a higher number of annual procedures report better outcomes, fewer complications, and lower early mortality, underscoring the importance of centralization and specialization to ensure quality and patient safety.

Likewise, consideration of individual clinical factors, such as associated comorbidities and the presence of rheumatological diseases, is essential to optimize patient selection and perioperative management, minimizing risks and promoting functional recovery.

Finally, the incorporation of accelerated rehabilitation protocols and early mobilization are essential pillars in the postoperative process, allowing for a reduction in complications and an improvement in patient autonomy. Total hip replacement surgery continues to advance toward less invasive techniques, greater technological integration, and a multidisciplinary approach that optimizes functional outcomes and the quality of life of the patient undergoing surgery.

Prospective studies with long-term follow-up and the standardization of clinical and functional variables are recommended to consolidate the available evidence and guide clinical practice based on robust and reproducible results.

REFERENCES

1. Zhao X, Yan S, Wang J, Liu Y. Direct and indirect comparisons in network meta-analysis of SuperPATH, direct anterior and posterior approaches in total hip arthroplasty. BMC Musculoskelet Disord. 2023;24(1):123. Disponible en: https://pubmed.ncbi.nlm.nih.gov/36202828/

2. Peng HM, Chen Q, Zhang Y, Li Z, Gao W. Comparison of anterior versus posterior approaches in total hip arthroplasty: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2020;21(1):78. Disponible en: https://pubmed.ncbi.nlm.nih.gov/32487060/

3. Masonis JL, Bourne RB. Surgical approach, abductor function, and total hip arthroplasty dislocation. Clin Orthop Relat Res. 2002;(405):46-53. Disponible en: https://pubmed.ncbi.nlm.nih.gov/12461355/

4. Wang Y, Guo L, Zhang W, Fan Y. Meta-analysis of SuperPATH versus posterior approach in total hip arthroplasty: clinical outcomes and complications. BMC Musculoskelet Disord. 2023;24(1):95. https://doi.org/10.1186/s12891-023-07126-x

5. Wang F, Zhang X, Li J, Chen L, Shen H. Accuracy of acetabular component alignment with surgical navigation systems in total hip arthroplasty: a systematic review. SICOT J. 2023;9:10. https://doi.org/10.1051/sicotj/2023009

6. Smith TO, Hing CB. The influence of hospital volume on outcomes following total hip arthroplasty: a systematic review. J Orthop Surg Res. 2019;14(1):16. Disponible en: https://pubmed.ncbi.nlm.nih.gov/30646912/

7. Prokopetz JJ, Losina E, Bliss RL, Wright J, Baron JA, Katz JN. Risk factors for revision of primary total hip arthroplasty: a systematic review. BMC Musculoskelet Disord. 2012;13:251. Disponible en: https://pubmed.ncbi.nlm.nih.gov/23241362/

8. Maradit Kremers H, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA, et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am. 2015;97(17):1386-97. Disponible en: https://pubmed.ncbi.nlm.nih.gov/26333733/

9. Chen Z, Liu S, Huang Y, Hu J. A review of the direct anterior approach in total hip arthroplasty: indications, techniques, outcomes, and complications. Orthop Surg. 2023;15(1):8-15. Disponible en: https://pubmed.ncbi.nlm.nih.gov/36469017/

10. Haughom BD, Gee AO, Smolenski RT. Complications in total hip arthroplasty: diagnosis and management. J Bone Joint Surg Am. 2020;102(4):370-81. Disponible en: https://pubmed.ncbi.nlm.nih.gov/32032194/

11. Li X, Wang C, Ma B, Liu Y, Xu H. Minimally invasive SuperPATH approach in total hip arthroplasty: a meta-analysis of randomized controlled trials. Medicine (Baltimore). 2024;103(5):e3125. Disponible en: https://pmc.ncbi.nlm.nih.gov/articles/PMC10849345/

12. Hernandez CJ, Sandoval-García F, Ahmed A, Pizones J. Learning curve and clinical outcomes of the direct anterior approach for total hip arthroplasty: a systematic review. J Orthop Surg. 2022;30(1):23094990221081330. Disponible en: https://pubmed.ncbi.nlm.nih.gov/35238246/

13. Zhao L, Liu M, Zhang J, Yang H. Comparison of recovery outcomes between SuperPATH and direct anterior approaches for total hip arthroplasty: a meta-analysis. Orthop Surg. 2023;15(4):1157-66. Disponible en: https://pubmed.ncbi.nlm.nih.gov/36797841/

14. Patel NK, Buller LT, Klika AK, Barsoum WK. Navigation and robotics in total hip arthroplasty: current concepts. Orthop Clin North Am. 2020;51(2):173-84. Disponible en: https://pubmed.ncbi.nlm.nih.gov/32138880/

15. Domb BG, El Bitar YF, Sadik AY, Stake CE, Perets I. Computer-assisted navigation and robotic technology in hip arthroscopy and total hip arthroplasty: an update. Orthop Clin North Am. 2021;52(3):333-42. Disponible en: https://pubmed.ncbi.nlm.nih.gov/34148610/

16. Kim YH, Kim JS, Park JW. Does surgeon volume affect outcomes following primary total hip arthroplasty? A systematic review. J Arthroplasty. 2018;33(3):962-7. Disponible en: https://pubmed.ncbi.nlm.nih.gov/29110983/

17. Hernandez NM, Barnes CL, Ong KL, Lau EC, Singh JA. Hospital and surgeon volume and outcomes after primary total hip arthroplasty: a systematic review. J Arthroplasty. 2018;33(9):2836-43. Disponible en: https://pubmed.ncbi.nlm.nih.gov/29773418/

18. Bosco JA 3rd, Cross MB, Keggi JM. Effects of hospital volume on total hip arthroplasty outcomes. J Am Acad Orthop Surg. 2021;29(13):e633-42. Disponible en: https://pubmed.ncbi.nlm.nih.gov/33835049/

19. Harris IA, Dao AT, Naylor JM. Centralization of total joint arthroplasty: impact on outcomes and costs. J Bone Joint Surg Am. 2022;104(9):793-9. Disponible en: https://pubmed.ncbi.nlm.nih.gov/35290285/

20. Khan SK, Malviya A, Muller SD, Patterson BM, Reed MR. Reduction in mortality and morbidity in hip replacement surgery with a fast-track protocol. Acta Orthop. 2014;85(1):26-31. Disponible en: https://pubmed.ncbi.nlm.nih.gov/24359028/

21. Bessette MC, Moussallem CD, Abdel MP, Mortazavi SMJ. Outcomes of total hip arthroplasty in patients with autoimmune rheumatic diseases: a systematic review. Semin Arthritis Rheum. 2021;51(2):334-42. Disponible en: https://pubmed.ncbi.nlm.nih.gov/33588251/

22. Goodman SM, Figgie M. Lower extremity arthroplasty in patients with inflammatory arthritis: preoperative and perioperative management. J Am Acad Orthop Surg. 2015;23(1):38-47. Disponible en: https://pubmed.ncbi.nlm.nih.gov/25538129/

23. Kehlet H. Fast-track hip and knee arthroplasty. Lancet. 2013;381(9878):1600-2. Disponible en: https://pubmed.ncbi.nlm.nih.gov/23663938/

24. Husted H, Holm G, Jacobsen S. Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients. Acta Orthop. 2008;79(2):168-73. Disponible en: https://pubmed.ncbi.nlm.nih.gov/18484241/

25. Ramadanov NN, Aliev RK, Ibrahimov DK. SuperPATH versus traditional hip replacement: updated meta-analysis. BMC Musculoskelet Disord. 2025;26(1):84. https://doi.org/10.1186/s12891-025-08471-9

FUNDING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

Conceptualization: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Data curation: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Formal analysis: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Research: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Methodology: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Project management: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Resources: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Software: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Supervision: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Validation: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Visualization: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Writing – original draft: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.

Writing – review and editing: Cevallos Navia Lincon Joan, Chávez Ruiz María Lisbeth, Quijije Sornoza Ingrid Paola, Franklin Antonio Vite Solorzano, Ruth Monserrate Delgado.