

Study of Comparative Outcomes of Different Bearing Surfaces in Total Hip Arthroplasty: A Prospective Study

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DOI: <https://doi.org/10.5281/zenodo.22185119>

Article Received: 05 August 2026, Accepted: 23 August 2026, Online First: 01 September 2026

ABSTRACT

Introduction: Bearing surface choice in total hip arthroplasty (THA) directly influences functional outcomes, complication rates, and implant survival. **Aim:** To compare outcomes of different bearing surfaces in THA with respect to functional recovery, complications, and revision surgery. **Methods:** A prospective study was conducted on 80 patients undergoing THA, divided into four groups of 20 each: MOP-HXLPE, COC (BioloX Delta), COP-HXLPE, and Oxinium + HXLPE. Functional outcomes were assessed using Harris Hip Score (HHS), while complications and revision surgeries were recorded. Statistical analysis included descriptive statistics and chi-square tests. **Results:** All groups showed significant postoperative improvement in HHS. The greatest gains were observed in COC (+50) and Oxinium + HXLPE (+49), compared to MOP-HXLPE (+41). Complications were highest in MOP-HXLPE (15% aseptic loosening, 10% dislocation, 10% osteolysis, 5% infection), while ceramic groups had minimal events. Revision surgery was most frequent in MOP-HXLPE (20%), absent in COC, and low in COP-HXLPE and Oxinium + HXLPE (5% each). **Conclusion:** Ceramic-on-ceramic and Oxinium + HXLPE bearings demonstrated superior functional outcomes, fewer complications, and lower revision rates compared to metal-on-polyethylene. Bearing surface selection plays a crucial role in ensuring long-term success of THA.

Keywords: Total Hip Arthroplasty (THA), Bearing Surfaces, Ceramic-on-Ceramic (COC), Oxinium + HXLPE

INTRODUCTION

Total hip arthroplasty (THA) has revolutionized the management of advanced hip disorders such as osteoarthritis and avascular necrosis, offering significant pain relief and functional restoration. Since its introduction in the mid-20th century, THA has become one of the most frequently performed elective surgeries worldwide, with survival rates exceeding 90% at ten years for modern implants¹. The choice of bearing surface plays a pivotal role in determining long-term outcomes, as it directly influences wear characteristics, biological reactions, and implant longevity.

Metal-on-metal (MoM) bearings initially gained popularity due to their low wear rates and improved range of motion. However, concerns regarding metal ion

release and adverse local tissue reactions have led to a decline in their use². Ceramic-on-ceramic (CoC) bearings, on the other hand, offer excellent wear resistance and biocompatibility, though they carry risks of squeaking and rare ceramic fracture³. Polyethylene-based bearings, particularly those with highly cross-linked polyethylene (HXLPE), have demonstrated reduced wear and lower rates of osteolysis compared to conventional polyethylene, making them a reliable option for long-term durability².

Comparative studies and meta-analyses suggest that ceramic bearings often provide superior functional outcomes and lower complication rates compared to polyethylene-based surfaces, while MoM implants, despite initial functional advantages, are associated with

higher revision risks due to biological complications²⁻³. With increasing life expectancy and rising demand for joint replacements, optimizing bearing surface selection is crucial to ensure both functional recovery and implant survival.

Thus, the present study aims to evaluate and compare the outcomes of different bearing surfaces in THA, focusing on functional improvement, complication rates, and revision surgery requirements.

Aim & Objectives

Aim

To evaluate and compare the functional outcomes, complication rates, and revision surgery requirements associated with different bearing surfaces used in total hip arthroplasty (THA).

Objectives

1. To assess preoperative and postoperative functional outcomes using the Harris Hip Score (HHS) across four bearing surface groups:
2. To identify and compare the incidence of complications such as aseptic loosening, dislocation, osteolysis, and infection among the different bearing surfaces.
3. To determine the frequency and causes of revision surgeries in each group and analyze their statistical significance.
4. To establish which bearing surface provides superior long-term clinical outcomes with respect to patient function, durability, and safety.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective comparative study conducted on 80 patients undergoing total hip arthroplasty. Patients were divided into four equal groups of 20 each, based on the bearing surface used:

- Group 1: Metal-on-Polyethylene with Highly Cross-Linked Polyethylene (MOP-HXLPE)
- Group 2: Ceramic-on-Ceramic (COC, Biolox Delta)
- Group 3: Ceramic-on-Polyethylene with Highly Cross-Linked Polyethylene (COP-HXLPE)
- Group 4: Oxinium-on-Polyethylene with Highly Cross-Linked Polyethylene (Oxinium + HXLPE)

Inclusion Criteria

1. Patients diagnosed with advanced hip osteoarthritis, avascular necrosis of the femoral head, or other degenerative hip conditions requiring THA.
2. Age between 40–70 years.
3. Medically fit for anesthesia and surgery.

4. Willing to provide informed consent and comply with follow-up protocol.

Exclusion Criteria

1. Active infection in or around the hip joint.
2. Severe systemic illness or contraindications to anesthesia.
3. Prior hip surgery or revision arthroplasty.
4. Unwillingness to participate or provide consent.

Procedure

All patients underwent THA using standardized surgical techniques performed by experienced orthopedic surgeons.

- **Preoperative Evaluation:** Each patient underwent detailed clinical examination, radiological assessment, and baseline functional scoring using the Harris Hip Score (HHS).
- **Anesthesia:** Spinal or general anesthesia was administered depending on patient suitability.
- **Surgical Approach:** A standard posterior or lateral approach was used to expose the hip joint.
- **Implant Selection:** Prosthesis was chosen according to the assigned group.
- **Fixation:** Cemented or uncemented fixation was performed depending on intraoperative requirements and bone quality.
- **Closure:** Wound closure was done in layers, with drains placed when necessary.
- **Postoperative Care:** Patients were monitored for vitals, pain control, and wound healing. Early mobilization was encouraged, with physiotherapy initiated on the first or second postoperative day.

Follow-up and Assessment

Patients were followed up at regular intervals. Functional recovery was assessed using Harris Hip Score (HHS), which showed significant improvement across all groups, with the highest gains in COC and Oxinium + HXLPE groups. Complications such as aseptic loosening, dislocation, osteolysis, and infection were recorded, with higher incidence in the MOP-HXLPE group. Revision surgeries were documented, with MOP-HXLPE showing the highest revision rate (20%), while COC had none.

Statistical Analysis

Data were analyzed using descriptive statistics. Mean and standard deviation were calculated for Harris Hip Scores. Chi-square test was applied to compare complication and revision rates between groups. A p-value of less than 0.05 was considered statistically significant.

OBSERVATION AND RESULTS

Table 1: Gender Distribution

Sr No	Group	Male n (%)	Females n (%)	Total N (%)
1	MOP-HXLPE	11 (55%)	9 (45%)	20 (25 %)
2	COC (BioloX Delta)	10 (50%)	10 (50%)	20 (25 %)
3	COP-HXLPE	12 (60%)	8 (40%)	20 (25 %)
4	Oxinium + HXLPE	11 (55%)	9 (45%)	20 (25 %)
Total N (%)		44 (55%)	36 (45%)	80 (100 %)

Across all four groups, the gender distribution was fairly balanced. In the MOP-HXLPE group, 55% were male and 45% female. The COC group had an equal split of 50% males and 50% females. The COP-HXLPE group showed a slight male predominance with 60% males and 40% females, while the Oxinium + HXLPE group had 55% males and 45% females. Overall, out of 80 patients, 44 (55%) were male and 36 (45%) were female, indicating a slight male predominance in the study population.

Table 2: Harris Hip Score (HHS)

Sr No	Group	Pre-op HHS (mean ± SD)	Post-op HHS (mean ± SD)	HHS Improvement (mean ± SD)
1	MOP-HXLPE	47 ± 7.0	88 ± 7.5	+41 ± 7.2
2	COC (BioloX Delta)	44 ± 6.0	94 ± 6.8	+50 ± 6.5
3	COP-HXLPE	46 ± 6.2	92 ± 6.5	+46 ± 6.3
4	Oxinium + HXLPE	45 ± 6.5	94 ± 6.7	+49 ± 6.4

All groups demonstrated significant improvement in Harris Hip Scores postoperatively. The MOP-HXLPE group improved from a mean pre-op score of 47 to 88 post-op, showing a mean gain of +41 points. The COC group had the highest improvement, rising from 44 to 94, with a gain of +50 points. The COP-HXLPE group improved from 46 to 92 (+46 points), while the Oxinium + HXLPE group improved from 45 to 94 (+49 points). These results suggest that ceramic-based bearings (COC and Oxinium + HXLPE) provided slightly superior functional outcomes compared to metal-on-polyethylene.

Table 3: Complications

Sr No	Group	Aseptic Loosening	Dislocation	Osteolysis	Infection	P value
1	MOP-HXLPE	3 (15%)	2 (10%)	2 (10%)	1 (5%)	0.002 (S)
2	COC (BioloX Delta)	0 (0%)	1 (5%)	0 (0%)	0 (0%)	0.14 (NS)
3	COP-HXLPE	1 (5%)	1 (5%)	0 (0%)	0 (0%)	0.38 (NS)
4	Oxinium + HXLPE	1 (5%)	1 (5%)	0 (0%)	0 (0%)	0.38 (NS)
Total N (%)		5 (6 %)	5 (6 %)	2 (2.5 %)	1 (1 %)	

The MOP-HXLPE group had the highest complication rates, with aseptic loosening in 15%, dislocation in 10%, osteolysis in 10%, and infection in 5%. In contrast, the COC group had minimal complications, with only one case of dislocation (5%). Both COP-HXLPE and Oxinium + HXLPE groups had low complication rates, each reporting one case of aseptic loosening (5%) and one case of dislocation (5%), with no osteolysis or infection. Overall, complications were present in 8 patients (10%), with aseptic loosening and dislocation being the most common.

Graph 1: Complications

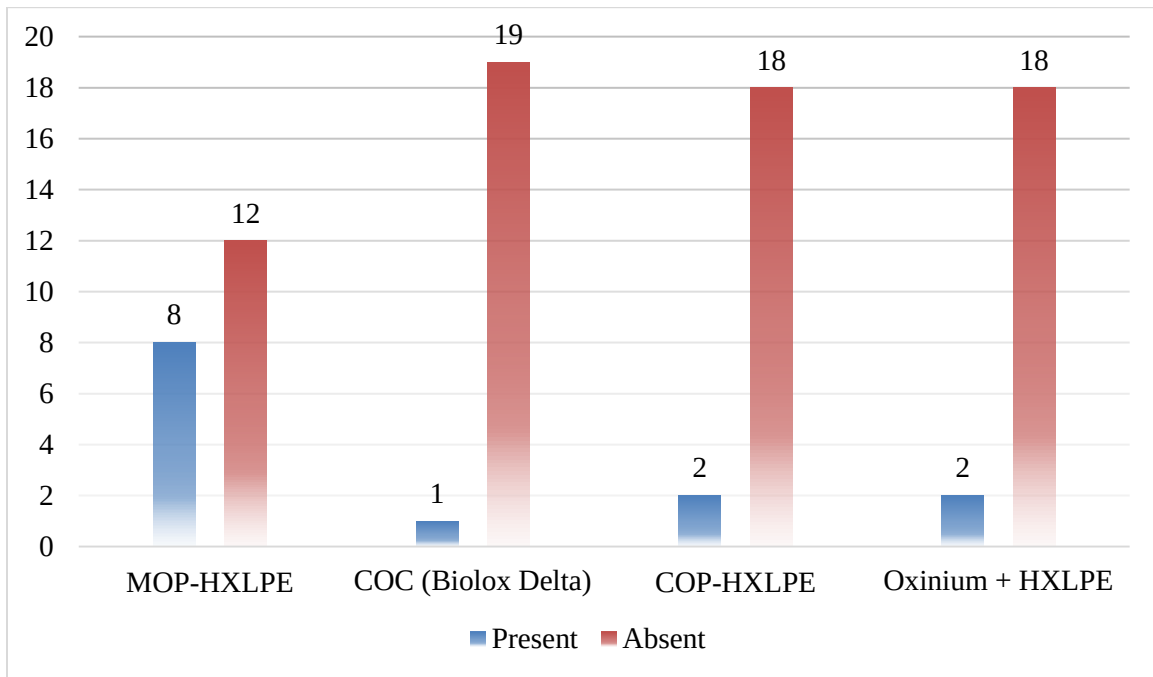


Table 4: Revision Surgery

Sr No	Group	Revision Cases (n, %)	No Revision (n, %)	Total N (%)	Chi square	P value
1	MOP-HXLPE	4 (20%)	16 (80%)	20 (25 %)	6.48	0.09 (NS)
2	COC (BioloX Delta)	0 (0%)	20 (100%)	20 (25 %)		
3	COP-HXLPE	1 (5%)	19 (95%)	20 (25 %)		
4	Oxinium + HXLPE	1 (5%)	19 (95%)	20 (25 %)		
Total N (%)		8 (10%)	72 (90%)	80 (100 %)	-	-

Revision surgery was most frequent in the MOP-HXLPE group, where 20% of patients required revision. The COC group had no revision cases, highlighting its durability. The COP-HXLPE and Oxinium + HXLPE groups each had only 5% revision rates. In total, 8 patients (10%) underwent revision surgery, while 72 patients (90%) did not. Although the chi-square test did not show statistical significance ($p = 0.09$), the trend suggests ceramic bearings had better long-term outcomes with fewer revisions.

DISCUSSION

The present study demonstrated that all bearing surfaces used in total hip arthroplasty (THA) resulted in significant improvement in Harris Hip Scores, with the greatest gains observed in the ceramic-on-ceramic (COC) and Oxinium + HXLPE groups. These findings are consistent with recent meta-analyses that reported superior functional outcomes with ceramic bearings compared to polyethylene-based surfaces¹. The durability of ceramic implants was further highlighted

by the absence of revision cases in the COC group, whereas the MOP-HXLPE group showed the highest revision rate (20%). Similar trends have been reported in international studies, where ceramic bearings were associated with lower revision risks and better long-term survival compared to metal-on-polyethylene².

Complication analysis in this study revealed that MOP-HXLPE had the highest incidence of aseptic loosening, dislocation, osteolysis, and infection. This aligns with prior evidence suggesting that polyethylene wear particles contribute to osteolysis and implant loosening, thereby increasing revision rates³. In contrast, ceramic bearings demonstrated minimal complications, with only isolated cases of dislocation. The reduced wear and inert biological profile of ceramics likely explain these favorable outcomes. Highly cross-linked polyethylene (HXLPE) also showed improved performance compared to conventional polyethylene, with lower wear rates and fewer osteolysis-related complications, supporting earlier findings that HXLPE reduces particle-induced bone resorption².

Recent registry data further corroborates these findings. A large-scale analysis from the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) confirmed that Oxinium-on-HXLPE combinations had the highest survivorship at 20 years, outperforming both metal and ceramic bearings⁴. Similarly, a 2024 study comparing ceramic-on-ceramic and metal-on-HXLPE bearings reported lower revision rates and fewer complications in ceramic groups, emphasizing the long-term reliability of ceramics⁵. Moreover, computational modeling of metal-on-polyethylene implants highlighted susceptibility to rim damage and increased wear under adverse loading, explaining the higher complication rates observed in polyethylene-based groups⁶.

The possible mechanism behind these results lies in the tribological properties of the bearing surfaces. Ceramic-on-ceramic bearings exhibit extremely low wear rates due to their hardness and smooth surface, which minimizes particle generation and inflammatory response². Oxinium, a zirconium alloy with a ceramicized surface, combines toughness with reduced wear, explaining its comparable outcomes to COC⁴. On the other hand, polyethylene, despite improvements with cross-linking, remains more susceptible to wear and particle release, leading to higher complication and revision rates^{2,3,6}.

Overall, the findings of this study reinforce the evidence that ceramic bearings, particularly COC and Oxinium + HXLPE, provide superior functional recovery, lower complication rates, and reduced need for revision surgery compared to metal-on-polyethylene. These results highlight the importance of bearing surface selection in optimizing long-term outcomes of THA.

Strengths of the Study

The major strengths of this study include its prospective comparative design and direct evaluation of four commonly used bearing-surface configurations in total hip arthroplasty. Equal numbers of patients were included in each group, allowing a balanced comparison of functional outcomes and postoperative complications. The study also evaluated clinically relevant outcomes using the Harris Hip Score in addition to documenting important implant-related complications and revision surgery. The simultaneous assessment of functional recovery, complications, and revision requirements provides a clinically relevant comparison of different bearing surfaces used in THA.

Future Implications and Research

Future research should include larger, multicenter prospective studies with longer follow-up periods to determine whether the functional advantages observed with ceramic-on-ceramic and Oxinium + HXLPE

bearings translate into improved long-term implant survivorship.

Future studies should also evaluate patient-reported outcome measures, activity levels, radiological evidence of wear and osteolysis, implant positioning, adverse local tissue reactions, and cost-effectiveness. Stratification according to age, diagnosis, activity level, fixation method, and implant design may further clarify which patient populations benefit most from specific bearing surfaces.

Long-term registry-based studies and adequately powered randomized comparative trials would provide stronger evidence regarding revision risk, implant survival, and the optimal bearing surface for different patient groups.

CONCLUSION

This prospective comparative study highlights that all bearing surfaces in total hip arthroplasty significantly improve functional outcomes, but ceramic-on-ceramic (COC) and Oxinium + HXLPE bearings demonstrated superior Harris Hip Score gains, fewer complications, and lower revision rates. In contrast, MOP-HXLPE showed the highest incidence of aseptic loosening, dislocation, and revision surgery. These findings suggest that ceramic-based bearings and advanced materials such as Oxinium + HXLPE provide better durability and long-term clinical outcomes, emphasizing the importance of bearing surface selection in optimizing patient recovery and implant longevity.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of JIU'S IIMS&R, Warudi, Badnapur, District Jalna, Maharashtra, India.

Written informed consent was obtained from all participants before enrollment in the study.

Consent for Publication

Written informed consent for publication of study-related information was obtained from the participants where applicable.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional and ethical restrictions.

Competing Interests

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this study.

Authors' Contributions

Dr. Ashish Pandharinath Sutrave: Conceptualization, study design, patient management, data collection, data interpretation, and manuscript preparation.

Dr. Nitin Mundhe: Clinical assessment, patient management, data collection, literature review, and critical revision of the manuscript.

Dr. Deepak Bhanghe: Surgical management, clinical supervision, data interpretation, and critical revision of the manuscript.

All authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Acknowledgements

The authors acknowledge the support of the Department of Orthopedics, JIIU'S IIMS&R, Warudi, Badnapur, District Jalna, Maharashtra, India, and all patients who participated in the study.

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