



COMPARATIVE ANALYSIS OF CERAMIC-ON-CERAMIC VERSUS CERAMIC-ON-POLYETHYLENE BEARINGS IN TOTAL HIP ARTHROPLASTY

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Abstract

Background: Total hip arthroplasty (THA) is one of the most successful orthopedic procedures for relieving pain and restoring function in patients with end-stage hip diseases. Bearing surface selection plays a critical role in implant longevity, wear characteristics, osteolysis, and functional outcomes. Ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP) bearings are widely used modern options, each with distinct biomechanical properties and clinical implications. While CoC bearings offer excellent wear resistance and reduced osteolysis, concerns remain regarding squeaking and ceramic fracture. Conversely, CoP bearings have evolved with highly cross-linked polyethylene, potentially reducing wear-related complications. Comparative clinical evidence remains necessary to guide optimal bearing selection.

Objective: To compare clinical outcomes, complication rates, and implant performance between ceramic-on-ceramic and ceramic-on-polyethylene bearing surfaces in patients undergoing primary total hip arthroplasty.

Methodology: A comparative analytical study was conducted at Sughra Shafi Medical Complex Narowal from July 2024 to June 2025 as of one year time involving patients who underwent primary THA using either CoC or CoP bearing surfaces. Patients were allocated into two groups based on the bearing type. Demographic data, operative details, and postoperative follow-up outcomes were recorded. Clinical outcomes were assessed using standardized hip function scores, including pain relief, range of motion, and functional mobility. Radiographic evaluation was performed to assess component positioning, wear, and signs of osteolysis or loosening. Complications such as dislocation, squeaking, infection, and revision surgery were documented. Statistical analysis was performed to compare outcomes between the two groups, with significance set at $p < 0.05$.

Results: Both groups demonstrated significant improvement in postoperative functional scores compared to preoperative status. The CoC group showed lower radiographic wear and absence of polyethylene-related osteolysis, while the CoP group demonstrated comparable functional outcomes with fewer reports of audible phenomena. Complication rates were low in both groups, with no statistically significant difference in infection or dislocation rates. Squeaking was observed exclusively in the CoC group, whereas mild radiographic wear was noted in some CoP cases without clinical significance.

Conclusion: Both ceramic-on-ceramic and ceramic-on-polyethylene bearings provide excellent clinical and functional outcomes in total hip arthroplasty. CoC bearings offer superior wear resistance, while CoP bearings provide reliable performance with fewer bearing-specific complications. Bearing selection should be individualized based on patient factors, surgeon preference, and long-term outcome considerations.

Keywords: Total hip arthroplasty; Ceramic-on-ceramic; Ceramic-on-polyethylene; Bearing surfaces; Implant wear; Orthopedic outcomes

Introduction

Total hip arthroplasty (THA) is widely recognized as one of the most effective and successful surgical interventions in modern orthopedics, providing substantial pain relief, restoration of mobility, and improved quality of life for patients suffering from end-stage hip disorders. Conditions such as primary osteoarthritis, avascular necrosis of the femoral head, inflammatory arthritis, and femoral neck fractures frequently necessitate hip replacement when conservative management fails. With increasing life expectancy, rising functional demands, and expanding indications for surgery, the number of THA procedures performed worldwide continues to grow steadily^(1,2).

Despite excellent short- and mid-term outcomes, long-term implant survival remains a critical concern, particularly in younger and more active patients. Aseptic loosening secondary to wear debris-induced osteolysis has historically been the leading cause of late failure in THA. Consequently, considerable research and technological advancements have focused on optimizing implant design, fixation methods, and bearing surface materials to reduce wear, improve durability, and enhance overall implant longevity⁽³⁾.

The bearing surface plays a pivotal role in determining the tribological performance of a hip prosthesis. Early hip replacements predominantly utilized metal-on-polyethylene bearings; however, conventional polyethylene was associated with significant wear particle generation, leading to periprosthetic osteolysis and implant loosening. This limitation prompted the development of alternative bearing surfaces, including ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP), which aim to minimize wear while maintaining excellent biomechanical compatibility⁽⁴⁾.

Ceramic materials possess several advantageous properties, including high hardness, superior scratch resistance, excellent wettability, and biocompatibility. These characteristics result in reduced friction and extremely low wear rates, making ceramic bearings particularly attractive for younger, high-demand patients. Ceramic-on-ceramic bearings, in particular, demonstrate the lowest wear rates among currently available bearing combinations and have been associated with reduced osteolysis and improved implant survival in long-term follow-up studies. However, concerns persist regarding specific complications such as ceramic fracture, component chipping, and audible squeaking, which may affect patient satisfaction and surgeon preference despite advancements in ceramic manufacturing technology⁽⁵⁾.

On the other hand, ceramic-on-polyethylene bearings combine the favorable surface properties of ceramic femoral heads with the improved wear characteristics of modern highly cross-linked polyethylene liners. Advances in polyethylene processing, including cross-linking and antioxidant stabilization, have significantly reduced wear rates compared to earlier generations of polyethylene. CoP bearings offer the advantages of lower cost, reduced risk of catastrophic material failure, and broader applicability across diverse patient populations. Furthermore, ceramic heads produce less

polyethylene wear than metal heads, potentially reducing the risk of osteolysis while maintaining reliable clinical performance⁽⁶⁾.

Although both CoC and CoP bearings are widely used in contemporary THA practice, the optimal bearing surface remains a subject of ongoing debate. Clinical outcomes, complication profiles, cost considerations, and patient-related factors all influence bearing selection. While CoC bearings are often favored for their excellent wear resistance, the clinical relevance of their unique complications must be weighed against the consistently favorable outcomes and lower risk profile associated with CoP bearings. Additionally, improvements in polyethylene technology have narrowed the performance gap between these two bearing options, making direct comparison increasingly relevant⁽⁷⁾.

Numerous studies have reported favorable results with both bearing surfaces; however, variations in study design, follow-up duration, patient demographics, and outcome measures have contributed to inconsistent conclusions. Some reports emphasize the superior wear performance of CoC bearings, while others highlight comparable functional outcomes and lower complication rates with CoP bearings. As the demand for long-lasting hip arthroplasty solutions continues to rise, especially among younger and active individuals, evidence-based guidance on bearing surface selection is essential⁽⁸⁾. Therefore, a comparative analysis of ceramic-on-ceramic versus ceramic-on-polyethylene bearings in total hip arthroplasty is warranted to better understand their relative clinical performance, complication rates, and functional outcomes. Such analysis can assist surgeons in making informed decisions tailored to individual patient needs and contribute to optimizing long-term success in total hip arthroplasty^(9, 10).

Methodology

Study Design and Setting

This comparative analytical study was conducted at Sughra Shafi Medical Complex Narowal from July 2024 to June 2025 as of one-year time. The study evaluated patients who underwent primary total hip arthroplasty (THA) using either ceramic-on-ceramic (CoC) or ceramic-on-polyethylene (CoP) bearing surfaces. The study was carried out over a defined study period, with postoperative follow-up conducted at regular intervals. Ethical approval was obtained from the institutional review board, and informed consent was taken from all participants prior to inclusion.

Study Population and Sample Selection

Patients undergoing primary THA during the study period were screened for eligibility. Eligible patients were allocated into two groups based on the bearing surface used during surgery:

- **Group A:** Ceramic-on-ceramic bearing
- **Group B:** Ceramic-on-polyethylene bearing

The choice of bearing surface was based on surgeon preference, patient age, activity level, and implant availability. A non-probability consecutive sampling technique was used.

Inclusion Criteria

Patients were included in the study if they met the following criteria:

1. Adults aged 18 years and above
2. Patients undergoing primary unilateral total hip arthroplasty
3. Indications for THA including:
 - Primary osteoarthritis of the hip
 - Avascular necrosis of the femoral head
 - Inflammatory arthritis
 - Post-traumatic arthritis
4. Use of either ceramic-on-ceramic or ceramic-on-polyethylene bearing surfaces
5. Ability to comply with postoperative follow-up and clinical evaluation
6. Provision of informed consent

Exclusion Criteria

Patients were excluded from the study if they met any of the following criteria:

1. Revision total hip arthroplasty
2. Previous surgery on the affected hip
3. Active or previous periprosthetic joint infection
4. Severe hip deformity requiring complex reconstruction
5. Neuromuscular disorders affecting gait or hip function
6. Pathological fractures or malignant conditions involving the hip
7. Incomplete clinical records or loss to follow-up

Surgical Technique and Postoperative Care

All procedures were performed by experienced orthopedic surgeons using standardized surgical techniques. A uniform surgical approach and cemented or uncemented fixation method were used according to patient bone quality and surgeon judgment. Perioperative antibiotic prophylaxis and thromboembolism prevention protocols were standardized for all patients. Postoperative rehabilitation followed a uniform protocol emphasizing early mobilization and physiotherapy.

Data Collection and Outcome Measures

Baseline demographic data, including age, gender, body mass index, diagnosis, and side of surgery, were recorded. Clinical outcomes were assessed using standardized hip function scoring systems, evaluating pain relief, range of motion, and functional capacity. Radiographic assessment was performed using serial anteroposterior and lateral hip radiographs to evaluate component positioning, wear, osteolysis, and loosening. Postoperative complications such as dislocation, infection, squeaking, implant failure, and need for revision surgery were documented.

Statistical Analysis

Data were analyzed using statistical software SPSS version 26. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. Comparative analysis between the two groups was performed using appropriate statistical tests, including the independent t-test and chi-square test. A p-value of <0.05 was considered statistically significant.

Results

A total of 40 patients who underwent primary total hip arthroplasty were included in the study. Of these, 20 patients received ceramic-on-ceramic (CoC) bearings (Group A) and 20 patients received ceramic-on-polyethylene (CoP) bearings (Group B). All patients completed the minimum follow-up period and were available for final analysis.

Baseline Demographic and Clinical Characteristics

Both groups were comparable with respect to age, gender distribution, body mass index, laterality, and indication for surgery. No statistically significant differences were observed between the two groups at baseline.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	CoC Group (n=20)	CoP Group (n=20)	p-value
Mean age (years)	51.8 $\pm$ 9.2	53.4 $\pm$ 8.7	0.56
Male : Female	13 : 7	12 : 8	0.75
Mean BMI (kg/m ²)	26.5 $\pm$ 3.1	27.0 $\pm$ 3.4	0.62
Side (Right/Left)	11 / 9	10 / 10	0.75
Osteoarthritis	13 (65%)	14 (70%)	0.74
Avascular necrosis	5 (25%)	4 (20%)	0.71

Inflammatory arthritis	2 (10%)	2 (10%)	1.00
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Functional Outcomes

Both groups demonstrated marked improvement in hip function following surgery. Postoperative functional scores were slightly higher in the CoC group; however, the difference between groups was not statistically significant.

Table 2: Comparison of Functional Outcome Scores

Outcome Measure	CoC Group	CoP Group	p-value
Preoperative score	43.2 ± 7.5	44.1 ± 8.0	0.71
Postoperative score	90.6 ± 5.8	88.9 ± 6.3	0.36
Mean improvement	47.4 ± 7.9	44.8 ± 8.2	0.29

Radiographic Outcomes

Radiographic evaluation at final follow-up showed satisfactory component positioning in both groups. No cases of implant loosening were observed. Polyethylene wear was noted in a small number of CoP patients without associated clinical symptoms.

Radiographic Parameter	CoC Group (n=20)	CoP Group (n=20)
Optimal component alignment	19 (95%)	19 (95%)
Evidence of osteolysis	0	2 (10%)
Radiographic wear	0	3 (15%)
Component loosening	0	0

Table 3: Radiographic Findings at Final Follow-up

Postoperative Complications

The overall complication rate was low in both groups. Audible squeaking was observed only in the CoC group. No statistically significant difference was observed in major complications between the groups.

Complication	CoC Group (n=20)	CoP Group (n=20)	p-value
Dislocation	1 (5%)	1 (5%)	1.00
Superficial infection	1 (5%)	1 (5%)	1.00
Deep infection	0	1 (5%)	0.31
Squeaking	3 (15%)	0	0.04
Revision surgery	0	1 (5%)	0.31

Table 4: Postoperative Complications

Overall Clinical Outcome

At final follow-up, the majority of patients in both groups achieved excellent or good outcomes, with no statistically significant difference in overall results.

Outcome Category	CoC Group (n=20)	CoP Group (n=20)
Excellent	14 (70%)	13 (65%)
Good	4 (20%)	5 (25%)
Fair	2 (10%)	2 (10%)
Poor	0	0

Table 5: Overall Clinical Outcome

Discussion

The present study compared clinical, radiographic, and complication outcomes between ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP) bearing surfaces in primary total hip arthroplasty. The findings demonstrate that both bearing options provide excellent functional improvement and

satisfactory short-term outcomes, with no statistically significant differences in overall clinical performance. These results support the continued use of both bearing surfaces in contemporary hip arthroplasty practice⁽¹¹⁾.

Functional outcome scores improved markedly in both groups following surgery, reflecting the well-established effectiveness of total hip arthroplasty in alleviating pain and restoring mobility. Although postoperative functional scores were marginally higher in the CoC group, the difference did not reach statistical significance. This suggests that, from a functional standpoint, both bearing surfaces perform comparably in the short term. Similar findings have been reported in previous studies, where improvements in highly cross-linked polyethylene have narrowed the functional performance gap between CoC and CoP bearings⁽¹²⁾.

Radiographic evaluation revealed excellent component positioning and an absence of implant loosening in both groups at final follow-up. Notably, no radiographic wear or osteolysis was observed in the CoC group, whereas mild polyethylene wear and limited osteolysis were identified in a small proportion of CoP patients. Although these findings did not translate into clinical symptoms or revision surgery, they are consistent with the superior wear characteristics of ceramic-on-ceramic bearings reported in long-term tribological studies. Nevertheless, the clinical relevance of minimal radiographic wear in CoP bearings remains uncertain, particularly given advancements in polyethylene technology⁽¹³⁾.

The complication profile differed slightly between the two groups. Audible squeaking was observed exclusively in the CoC group, a finding consistent with existing literature and attributed to ceramic surface interactions, component positioning, and patient activity levels. While squeaking did not necessitate revision in the present study, it may influence patient satisfaction and should be discussed during preoperative counseling. Other complications, including dislocation and infection, occurred at similarly low rates in both groups, indicating that bearing choice did not significantly impact overall safety⁽¹⁴⁾.

The findings of this study must be interpreted in light of certain limitations. The relatively small sample size and short follow-up period limit the ability to detect rare complications and long-term differences in implant survival. Additionally, bearing selection was not randomized, which may introduce selection bias. Despite these limitations, the study provides valuable comparative data and reflects real-world clinical practice^(15, 16).

In conclusion, both ceramic-on-ceramic and ceramic-on-polyethylene bearings offer excellent short-term outcomes in total hip arthroplasty. Bearing selection should be individualized, taking into account patient age, activity level, risk tolerance, and surgeon experience. Larger, long-term studies are required to further clarify differences in wear-related outcomes and implant survivorship.

Limitations

This study has several limitations that should be considered. First, the sample size was relatively small (n=40), which limits the statistical power and may not capture rare complications or subtle differences between groups. Second, the follow-up period was short, preventing assessment of long-term wear, osteolysis, or implant survivorship. Third, bearing allocation was not randomized, introducing potential selection bias based on surgeon preference or patient characteristics. Additionally, functional outcomes were measured using standard scoring systems without patient-reported quality-of-life metrics. Despite these limitations, the study provides valuable comparative insights into short-term outcomes of ceramic-on-ceramic and ceramic-on-polyethylene bearings.

Implications

The findings of this study have important clinical and surgical implications for total hip arthroplasty. Both ceramic-on-ceramic and ceramic-on-polyethylene bearings provide excellent short-term functional outcomes and low complication rates, supporting their continued use in diverse patient populations. Surgeons can individualize bearing selection based on patient age, activity level, cost considerations, and risk tolerance, while providing informed preoperative counseling regarding potential complications such as squeaking or wear. Additionally, the study highlights the need for

ongoing monitoring of polyethylene wear in CoP implants and encourages further long-term research to guide evidence-based decisions for optimal implant longevity and patient satisfaction.

Conclusion

Both ceramic-on-ceramic and ceramic-on-polyethylene bearing surfaces provide excellent functional and clinical outcomes in primary total hip arthroplasty. The present study demonstrates comparable improvement in hip function, low complication rates, and satisfactory radiographic findings with both bearing options. While ceramic-on-ceramic bearings showed superior wear characteristics, ceramic-on-polyethylene bearings achieved similar clinical results with fewer bearing-specific issues. Therefore, bearing selection should be individualized based on patient characteristics, activity level, and surgeon preference. Larger studies with longer follow-up are required to determine long-term survivorship and wear-related differences between these bearing surfaces.

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