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Ceramic-On-Ceramic Vs Ceramic-On-Polyethylene in Total Hip Replacement a Comparative Study

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Abstract

Background: This study compared clinical, functional, radiological, and complication-related outcomes of ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP) bearings in total hip arthroplasty (THA). ***Methods***: A total of 100 patients undergoing primary THA were included, with 50 patients each in the CoC and CoP groups. Functional outcome was assessed using the Harris Hip Score (HHS), along with radiological findings and postoperative complications. ***Results***: Mean HHS improved from 43.6 ± 7.8 to 91.2 ± 4.9 in the CoC group and from 44.2 ± 8.1 to 89.1 ± 5.6 in the CoP group (within-group p<0.001). Excellent/good outcomes were achieved in 94.0% and 90.0%, respectively. Osteolysis occurred in 0% versus 4.0%, while squeaking occurred in 8.0% versus 0%. Revision was required in 2.0% and 4.0% of patients, respectively. ***Conclusion***: Both CoC and CoP bearings provided significant functional improvement with satisfactory radiological outcomes. CoC showed less osteolysis but more bearing-specific complications, while overall complication and revision rates were comparable.

INTRODUCTION

Total hip arthroplasty (THA) is one of the most successful reconstructive procedures in orthopaedic surgery and is widely used for the management of end-stage hip disorders, including osteoarthritis, avascular necrosis of the femoral head, inflammatory arthritis, and post-traumatic arthritis. It provides substantial pain relief, restores mobility, and improves functional capacity and quality of life.[1,2] With increasing life expectancy and the growing number of younger and physically active patients undergoing THA, greater emphasis is now being placed on long-term implant survival and reduction of prosthesis-related complications.[3]Bearing-surface wear is an important factor influencing the longevity of THA. Wear particles generated from the articulating surfaces may initiate a biological response, leading to periprosthetic osteolysis, progressive bone loss, aseptic loosening, and eventual implant failure.[4,5] These complications are particularly relevant in younger and active patients because of their higher functional demands and longer expected implant survival. Consequently, considerable efforts have been directed toward developing bearing surfaces that minimise wear and improve prosthetic longevity.Ceramic materials have emerged as an attractive bearing option because of their high hardness, scratch resistance, biocompatibility, and favourable tribological properties. Ceramic-on-ceramic (CoC) articulation has a low coefficient of friction and produces substantially less wear debris than conventional polyethylene-based bearings.[6,7] These characteristics may reduce wear-induced osteolysis and make CoC bearings particularly attractive for younger and more active patients.[6] However, CoC articulation has specific limitations, including bearing-related noise or squeaking and a small risk of ceramic component fracture.[8]Ceramic-on-polyethylene (CoP) articulation combines a ceramic femoral head with a polyethylene acetabular liner and represents an important alternative bearing surface in contemporary THA. It retains the favourable surface characteristics of ceramic while avoiding some of the complications associated with ceramic acetabular liners. Nevertheless, polyethylene wear and its potential contribution to osteolysis and long-term implant failure remain important considerations.[9,10]Several clinical studies have directly compared CoC and CoP articulations. Although CoC bearings demonstrate favourable wear characteristics, these advantages do not necessarily translate into superior clinical and functional outcomes. Comparative studies have reported satisfactory outcomes with both bearing combinations, while the relative risks of wear, bearing-related complications, and implant failure vary according to the articulation used.[9-11] Furthermore, evidence evaluating optimal bearing surfaces in younger patients has demonstrated that selection remains challenging because each bearing combination has distinct advantages and limitations.[12]Thus, the choice of bearing surface in THA should consider not only wear characteristics but also functional outcomes, radiological changes, bearing-specific complications, patient age and activity level, and anticipated implant longevity. Direct comparison of CoC and CoP bearings may provide clinically relevant evidence to guide appropriate bearing selection. Hence, the present study was designedto compare ceramic-on-ceramic and ceramic-on-polyethylene bearing surfaces in patients undergoing total hip arthroplasty, with particular emphasis on clinical and functional outcomes, radiological findings, and postoperative complications.

MATERIALS AND METHODS

This comparative study was conducted in the Department of Orthopaedics at a tertiary care hospital. A total of 100 patients undergoing primary total hip arthroplasty (THA) for symptomatic end-stage hip disease were included. Patients were divided into two groups according to the bearing surface used:
Group CoC (n=50): THA with ceramic-on-ceramic articulation.
Group CoP (n=50): THA with ceramic-on-polyethylene articulation.

Inclusion Criteria

Adult patients of either sex undergoing primary THA for end-stage hip disease with significant pain and functional limitation were included. Patients who were willing to participate and available for the scheduled postoperative follow-up were considered eligible.

Exclusion Criteria

Patients undergoing revision THA, those with active local or systemic infection, pathological fractures secondary to malignancy, severe neuromuscular disorders affecting hip function, major hip deformity precluding standard THA, or inadequate postoperative follow-up were excluded.

Preoperative Evaluation

All patients underwent detailed history taking, clinical examination, and radiological assessment. Age, sex, affected side, primary diagnosis, duration of symptoms, and associated comorbidities were recorded. Hip pain, gait, range of motion, and functional limitation were evaluated. Standard radiographs of the pelvis and affected hip were obtained. Preoperative functional status was assessed using the Harris Hip Score (HHS).

Surgical Technique

All patients underwent primary THA using a standard surgical technique under appropriate anaesthesia and aseptic precautions. The acetabulum and femoral canal were prepared sequentially, and appropriately sized components were implanted. In the CoC group, a ceramic femoral head articulated with a ceramic acetabular liner, whereas in the CoP group, a ceramic femoral head articulated with a polyethylene liner. Component position, hip stability, range of motion, and limb length were assessed before wound closure.

Postoperative Management and Follow-up

Postoperative analgesia, antibiotic prophylaxis, thromboprophylaxis, physiotherapy, and rehabilitation were provided according to the institutional protocol. Early mobilization was initiated as clinically appropriate, followed by progressive weight bearing and strengthening exercises.Patients were assessed at scheduled follow-up visits for pain, gait, range of motion, and functional recovery. Functional outcome was evaluated using the HHS. Follow-up radiographs were assessed for component position, radiolucent lines, osteolysis, migration, and implant loosening. Complications including infection, dislocation, periprosthetic fracture, aseptic loosening, bearing-related noise or squeaking, ceramic fracture, and revision surgery were recorded.

Outcome Measures

The primary outcome was postoperative functional outcome assessed using the HHS. Secondary outcomes included improvement in pain and mobility, radiological outcomes, osteolysis, implant loosening, bearing-related complications, other postoperative complications, and requirement for revision surgery.

Statistical Analysis

Data were analysed using SPSS.21statistical software. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), as appropriate, while categorical variables were presented as frequencies and percentages. Continuous variables were compared using the independent-samples t-test or Mann–Whitney U test, and categorical variables using the Chi-square test or Fisher's exact test. Changes in functional scores during follow-up were assessed using the paired t-test or Wilcoxon signed-rank test, as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 100 patients were included, with 50 each in the ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP) groups. Baseline demographic and clinical characteristics were comparable between groups, including age, sex, BMI, affected side, symptom duration, and preoperative Harris Hip Score (HHS) (all p>0.05) (Table 1). Avascular necrosis was the most common primary diagnosis (42.0% vs 40.0%), followed by primary osteoarthritis (30.0% vs 32.0%), with no significant difference in diagnostic distribution (p=0.928) (Table 2).HHS improved significantly in both groups during follow-up (within-group p<0.001) (Table 3). At 12 months, the mean HHS was significantly higher in the CoC group than in the CoP group (91.2 ± 4.9 vs 89.1 ± 5.6; p=0.049), although the mean overall improvement was comparable (47.6 ± 8.4 vs 44.9 ± 8.7; p=0.117). Excellent or good functional outcomes were achieved by 94.0% of CoC and 90.0% of CoP patients (p=0.715) (Table 4; Figure 1).Radiological outcomes were comparable between groups, with satisfactory component positioning in 96.0% of CoC and 94.0% of CoP patients. No significant differences were observed in radiolucent lines, osteolysis, component migration, or aseptic loosening (Table 5).Postoperative complications were infrequent and comparable between groups (Table 6; Figure 2). Squeaking/bearing noise occurred only in the CoC group (8.0% vs 0%; p=0.117), while one ceramic fracture (2.0%) was also observed in this group. Revision surgery was required in 2.0% of CoC and 4.0% of CoP patients (p=1.000).At 12 months, HHS showed significant negative correlations with age (r=−0.31, p=0.002), BMI (r=−0.22, p=0.028), and symptom duration (ρ=−0.27, p=0.007), while preoperative HHS showed a positive correlation (r=0.42, p<0.001) (Table 7; Figure 3).

Table 1. Baseline demographic and clinical characteristics

Parameter	CoC (n=50)	CoP (n=50)	p-value	Statistical test
Age (years), mean ± SD	46.8 ± 9.2	48.1 ± 8.7	0.469	Independent t-test
Male, n (%)	32 (64.0)	30 (60.0)	0.680	Chi-square test
Female, n (%)	18 (36.0)	20 (40.0)		
BMI (kg/m²), mean ± SD	25.4 ± 3.1	25.8 ± 3.4	0.540	Independent t-test
Right hip, n (%)	27 (54.0)	29 (58.0)	0.687	Chi-square test
Left hip, n (%)	23 (46.0)	21 (42.0)		
Symptom duration (months), mean ± SD	18.7 ± 7.4	19.3 ± 7.8	0.694	Independent t-test
Preoperative HHS, mean ± SD	43.6 ± 7.8	44.2 ± 8.1	0.707	Independent t-test

Table 2. Distribution according to primary diagnosis

Diagnosis	CoC (n=50)	CoP (n=50)	p-value	Statistical test
Avascular necrosis	21 (42.0%)	20 (40.0%)	0.928	Chi-square test
Primary osteoarthritis	15 (30.0%)	16 (32.0%)		
Post-traumatic arthritis	8 (16.0%)	7 (14.0%)		
Inflammatory/other arthritis	6 (12.0%)	7 (14.0%)		

Table 3. Comparison of Harris Hip Score during follow-up

Time point	CoC (n=50), mean ± SD	CoP (n=50), mean ± SD	p-value	Statistical test
Preoperative	43.6 ± 7.8	44.2 ± 8.1	0.707	Independent t-test
3 months	76.8 ± 6.9	75.9 ± 7.2	0.525	
6 months	86.5 ± 5.8	84.9 ± 6.3	0.190	
12 months	91.2 ± 4.9	89.1 ± 5.6	0.049	
Mean improvement at 12 months	47.6 ± 8.4	44.9 ± 8.7	0.117	
Within-group p-value	<0.001	<0.001	—	Paired t-test

Table 4. Functional outcome according to Harris Hip Score at 12 months

HHS category	CoC (n=50)	CoP (n=50)	p-value	Statistical test
Excellent (90–100)	34 (68.0%)	29 (58.0%)	0.572	Chi-square/Fisher's exact test
Good (80–89)	13 (26.0%)	16 (32.0%)		
Fair (70–79)	3 (6.0%)	4 (8.0%)		
Poor (<70)	0	1 (2.0%)		
Excellent/Good	47 (94.0%)	45 (90.0%)	0.715	Fisher's exact test

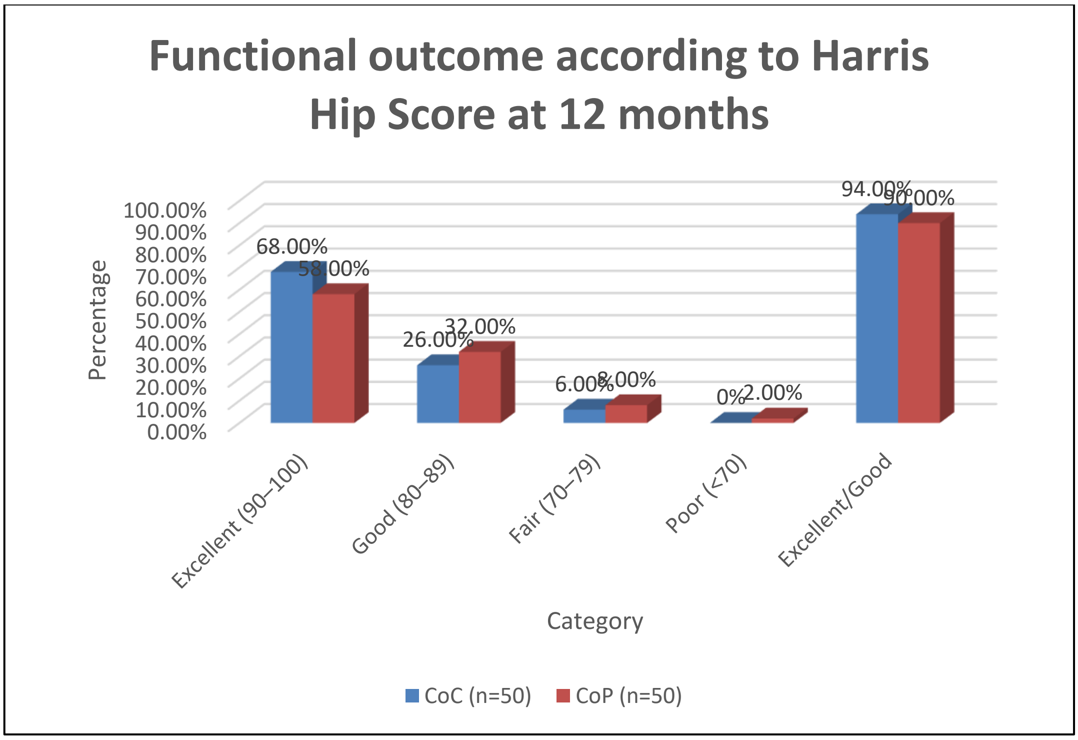

Figure 1. Functional outcome according to Harris Hip Score at 12 months

Table 5. Radiological outcomes at final follow-up

Radiological finding	CoC (n=50)	CoP (n=50)	p-value	Statistical test
Satisfactory component position	48 (96.0%)	47 (94.0%)	1.000	Fisher's exact test
Radiolucent lines	2 (4.0%)	4 (8.0%)	0.678	Fisher's exact test
Osteolysis	0	2 (4.0%)	0.495	Fisher's exact test
Component migration	1 (2.0%)	1 (2.0%)	1.000	Fisher's exact test
Aseptic loosening	0	1 (2.0%)	1.000	Fisher's exact test

Table 6. Postoperative and bearing-related complications

Complication	CoC (n=50)	CoP (n=50)	p-value	Statistical test
Superficial infection	1 (2.0%)	2 (4.0%)	1.000	Fisher's exact test
Dislocation	1 (2.0%)	2 (4.0%)	1.000	
Periprosthetic fracture	1 (2.0%)	1 (2.0%)	1.000	
Squeaking/bearing noise	4 (8.0%)	0	0.117	
Ceramic fracture	1 (2.0%)	0	1.000	
Revision surgery	1 (2.0%)	2 (4.0%)	1.000	

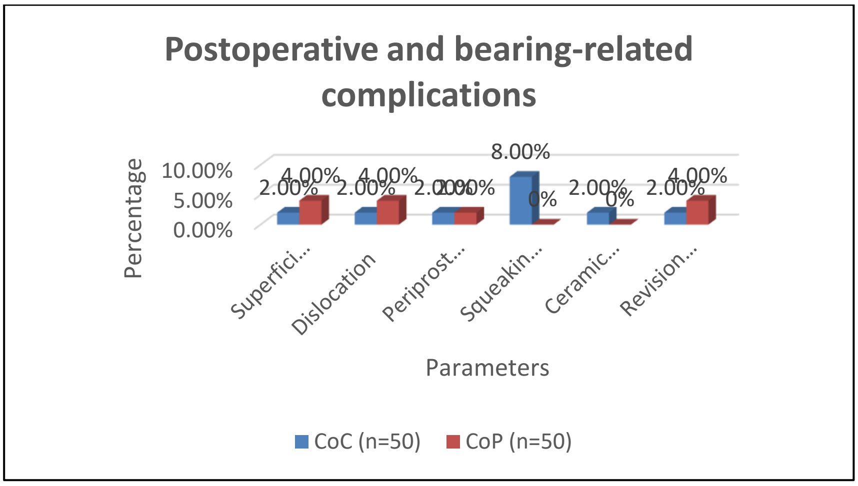

Figure 2. Postoperative and bearing-related complications

Table 7. Correlation of clinical variables with 12-month Harris Hip Score

Variable	Correlation coefficient (r/ρ)	p-value	Statistical test
Age	−0.31	0.002	Pearson correlation
BMI	−0.22	0.028	Pearson correlation
Duration of symptoms	−0.27	0.007	Spearman correlation
Preoperative HHS	0.42	<0.001	Pearson correlation
12-month HHS improvement	0.36	<0.001	Pearson correlation

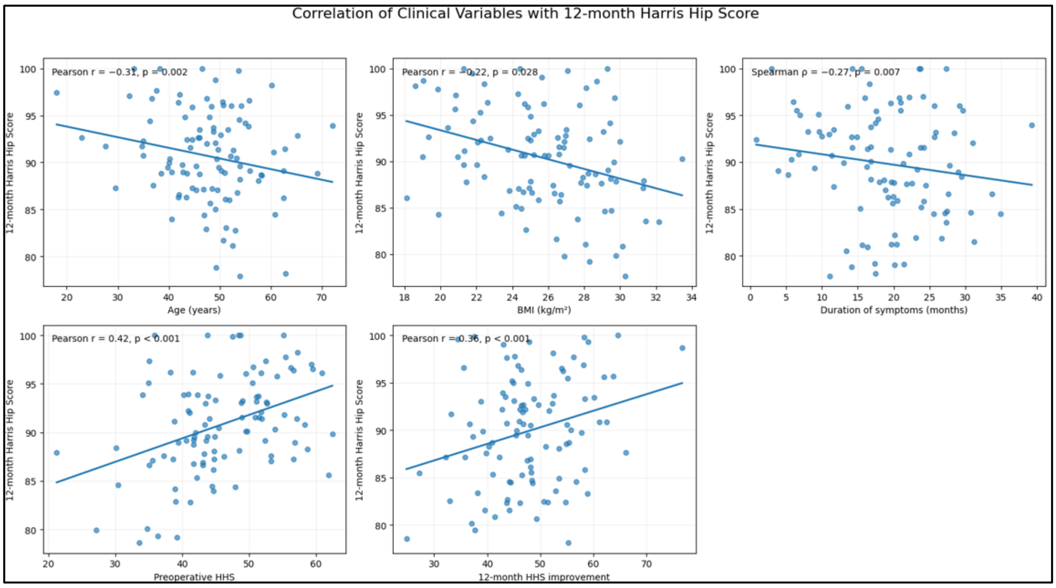

Figure 3. Correlation of clinical variables with 12-month Harris Hip Score

DISCUSSION

The present study compared functional, radiological, and complication outcomes of ceramic-on-ceramic (CoC) and ceramic-on-polyethylene (CoP) bearings following total hip arthroplasty. Both groups showed substantial functional improvement, with largely comparable radiological and complication outcomes.The groups were comparable for age (46.8 ± 9.2 vs 48.1 ± 8.7 years), BMI (25.4 ± 3.1 vs 25.8 ± 3.4 kg/m²), symptom duration (18.7 ± 7.4 vs 19.3 ± 7.8 months), and preoperative HHS (43.6 ± 7.8 vs 44.2 ± 8.1; all p>0.05). Avascular necrosis was the commonest indication (42.0% vs 40.0%), followed by primary osteoarthritis (30.0% vs 32.0%). Thus, the groups were sufficiently comparable for assessment of bearing-related outcomes.HHS improved significantly from 43.6 ± 7.8 to 91.2 ± 4.9 in CoC and from 44.2 ± 8.1 to 89.1 ± 5.6 in CoP (within-group p<0.001). At 12 months, CoC had a slightly higher HHS (91.2 vs 89.1; p=0.049), although mean improvement was comparable (47.6 vs 44.9 points; p=0.117). Excellent/good outcomes were achieved in 94.0% of CoC and 90.0% of CoP patients (p=0.715).

Similarly, Beaupre et al. [13] randomized 92 patients (48 CoC and 44 ceramic-on-Crossfire polyethylene) and found substantial functional improvement with both bearings without a significant long-term functional advantage of either articulation. Their study also demonstrated lower wear with CoC, approximately 0.018 mm/year compared with 0.092 mm/year for polyethylene. Thus, our results support the finding that both bearings provide satisfactory functional recovery.Satisfactory component positioning was observed in 96.0% of CoC and 94.0% of CoP patients. Radiolucent lines occurred in 4.0% versus 8.0%, osteolysis in 0% versus 4.0%, component migration in 2.0% each, and aseptic loosening in 0% versus 2.0%; none differed significantly.

Beaupre et al. [13] similarly reported acetabular osteolysis in two CoC versus three polyethylene hips and femoral osteolysis in six versus 12 hips during longer follow-up, despite greater polyethylene wear. Stilling et al. [14], in a phantom RSA study, demonstrated that radiostereometric techniques can detect polyethylene wear with considerably greater accuracy than conventional approaches, emphasizing that subtle wear may require sensitive measurement and longer follow-up. Our 12-month radiographic findings should therefore be interpreted as early outcomes.Squeaking/bearing noise occurred in 4 (8.0%) CoC patients but none of the CoP patients (p=0.117). Kim et al. [15], in a cohort of 602 CoC hips (310 third-generation and 292 fourth-generation), similarly found that newer fourth-generation ceramic bearings improved mid-term outcomes but did not eliminate bearing-related noise. This supports our observation that squeaking remains a characteristic CoC complication.Ceramic fracture occurred in one CoC patient (2.0%) and none in the CoP group. Yoon et al. [15], in their meta-analysis of contemporary CoC THA, showed that ceramic fracture is uncommon with modern ceramics but has not been completely eliminated. Beaupre et al. [13] also reported a CoC revision due to ceramic head fracture during long-term follow-up. Thus, our finding is consistent with the recognized, although uncommon, complication profile of CoC bearings.Dislocation occurred in 2.0% of CoC and 4.0% of CoP patients, while superficial infection occurred in 2.0% versus 4.0%, periprosthetic fracture in 2.0% versus 2.0%, and revision surgery in 2.0% versus 4.0%; all differences were nonsignificant.Dargel et al. [16] described THA dislocation as multifactorial, influenced by patient factors, surgical approach, component positioning, implant design, and soft-tissue tension. Similarly, Lu et al. [17] emphasized patient-, surgery-, and implant-related factors in postoperative instability and reported that approximately two-thirds of dislocations can be managed conservatively, while about one-third require surgery. These observations support our finding that dislocation rates were low and did not differ significantly according to bearing type.Age ($r=-0.31$, $p=0.002$), BMI ($r=-0.22$, $p=0.028$), and symptom duration ($\rho=-0.27$, $p=0.007$) correlated negatively with 12-month HHS, whereas preoperative HHS showed a positive correlation ($r=0.42$, $p<0.001$). These findings indicate that postoperative function is influenced by patient and preoperative characteristics in addition to bearing selection.

CONCLUSION

Both ceramic-on-ceramic and ceramic-on-polyethylene bearings provided significant functional improvement and satisfactory radiological outcomes following total hip arthroplasty. CoC showed slightly better 12-month functional scores and less osteolysis, whereas bearing-related squeaking and ceramic fracture were observed more frequently with CoC. Overall, both bearing surfaces were effective, with no major difference in complication or revision rates.

LIMITATIONS

The study was limited by its relatively small sample size and short follow-up period, which restricted assessment of long-term wear, osteolysis, implant survival, and revision. Larger prospective studies with longer follow-up are required to establish the long-term comparative performance of these bearing surfaces.

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