

# Ceramic on Ceramic or Ceramic-on-polyethylene for Total Hip Arthroplasty: A Systemic Review and Meta-analysis of Prospective Randomized Studies

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## Abstract

**Background:** Wear debris of polyethylene has become a restraining factor of the durability for total hip arthroplasty (THA). Ceramic on ceramic (COC) has better wear resistance while the squeaking sound and prosthesis fracture are of concern. It is still a controversy that bearing couples are better for THA.

**Methods:** We performed a systematic review of all English articles identified from PubMed (1966-), Embase (1980-) and the Cochrane Library. Clinical outcomes, complications, revision rates, and radiographic outcomes of COC-THA and ceramic on polyethylene (COP)-THA were compared and evaluated.

**Results:** Eight prospective randomized trials enrolling a total of 1508 patients and 1702 THA surgeries were identified. Our results demonstrated the prosthesis fracture and the squeaking sound is significantly higher in COC group and higher wear rate of the COP. Hip function, loosening rate, dislocation rate, revision rate, and the osteolysis rate were comparable between two groups. According to Grading of Recommendations Assessment, Development and Evaluation system assessment, the strength of evidence was high for prosthesis fracture, dislocation, osteolysis, and moderate for radiolucent line or loosening, hip noise, and revision.

**Conclusions:** Up to now, there is insufficient evidence to identify any clinical advantage of COC compared with COP. Longer follow-up of larger randomized trial is needed to clarify the outcomes.

**Key words:** Ceramic-on-ceramic; Meta-analysis; Randomized Studies; Total Hip Arthroplasty

## INTRODUCTION

Total hip arthroplasty (THA) is one of the most successful surgeries to treat severe arthritis, trauma and congenital diseases of the hip.<sup>[1,2]</sup> Over 200,000 THAs are performed in the United States every year, and the demand for primary THAs is expected to grow by 174% to 572,000 by 2030.<sup>[3]</sup> However, young active patients are still facing difficulty in receiving such surgery as substantial numbers of patients require revision surgery because of wear instability, loosening, or other mechanical failures.<sup>[4,5]</sup> Periprosthetic osteolysis is regarded as an important factor in the durability of a total hip prosthesis, and many studies have suggested osteolysis is related to wear and the number of debris particles.<sup>[6,7]</sup> Therefore, the use of material with low wear debris production has become an attractive alternative in young active patients. It has been reported that ceramic on

ceramic (COC) prostheses have high wear resistance and, therefore, produce less wear debris.<sup>[8]</sup>

There has been a significant expansion in the worldwide use of COC bearings in the past decade. Wear rates and osteolytic potential of COC bearings have been shown to be lower than those of ceramic on polyethylene (COP) bearings in laboratory experiments.<sup>[9]</sup> However, COC bearings may produce squeaking sound and may be more fragile than the polyethylene (PE).<sup>[10]</sup> There has been concern regarding the increased use of COC-THA as an alternative to contemporary COP-THA, and the choice remains controversial.<sup>[11]</sup>

This meta-analysis aimed to address that clinical choice based on the results of published research. We evaluated and compared complications, revision rates, clinical outcomes and radiographic outcomes of COC-THA and COP-THA. To our knowledge, this is the first analysis to evaluate all the available data on COC implants compared with COP implants for THA. The inclusion of only prospective

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randomized trials enhances the level of evidence compared with previous literature reviews or other single trials.

## METHODS

### Search strategy

We conducted a meta-analysis of all English articles identified from PubMed (1966–), Embase (1980–) and the Cochrane Library. Additional studies were identified by contacting experts and searching reference lists. We used Medical Subject Headings terms and free words, including ceramic (COC, alumina), PE and hip arthroplasty (THA, total hip replacement).

### Selection criteria

The present meta-analysis followed the PRISMA guidelines.<sup>[12,13]</sup> Each publication was independently reviewed by two investigators who were blinded to the journal, author, institution at which the study was performed and the date of publication. Eligible studies compared COC-THA and COP-THA and provided sufficient numerical information on at least one of the following prespecified endpoints: Revision for any cause, local and general complications, radiographic outcomes.

### Data extraction

Two investigators independently extracted data from the studies using a structured form. The following information was sought from each report: Year of publication, enrollment period, country and region, number of patients, study design, mean age, percentage male, loss to follow-up and materials design. The reviewers also extracted and electronically recorded event rates with nominators and denominators for different endpoints, as well as the means and standard deviations for functional scores and quality of life assessments. The reviewers resolved disagreements by discussion with a third investigator.

### Quality assessment

Two independent reviewers assess methodological quality of clinical trials using the Cochrane Collaboration recommendations. The trials were assessed in the following aspects: Random sequence generation, allocation concealment, blinding of outcome assessments, incomplete outcome data, selective reporting and other biases. An arbiter was consulted to reconcile any disagreements.

### Evidence grading

We graded the quality of evidences for our outcomes using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, and analyzed the data with GRADE profiler software (GRADEpro. [Computer program]. Version 3.6 for Windows. Jan Brozek, Andrew Oxman, Holger Schünemann). Levels of evidence strength were classified into: (1) High – further research is very unlikely to change our confidence in the estimate of effect. (2) Moderate – further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. (3) Low – further research is

very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. (4) Very low – we are very uncertain about the estimate.

### Statistical analysis

For each included study, risk ratio (*RR*) and 95% confidence intervals (*CI*s) were calculated for dichotomous outcomes, while weighted mean differences and 95% *CI* were calculated for continuous outcomes. Statistical heterogeneity was assessed using the *I*<sup>2</sup> value and Chi-squared test. A *P* > 0.1 and an *I*<sup>2</sup> ≤ 50% were considered as no statistical heterogeneity and an application of fixed-effects model was used to estimate the overall summary effect sizes. Otherwise, random-effects model was adopted, and a subgroup analysis or sensitivity analysis would be carried out. All analyses were completed with Review Manager Software (RevMan 5.2, Cochrane Collaboration, Denmark) and *P* < 0.05 was considered as significant.

## RESULTS

### Search results

The search strategy retrieved 1163 unique citations. Of these, 1148 citations were excluded after the first or second screening based on titles or abstracts, and 15 articles remained for full-text review. The related publications were assessed for overlapping and unique information relevant to this analysis. After a full review of the text, only prospective randomized controlled trials (RCTs) were included. Eight studies<sup>[14-21]</sup> enrolling a total of 1508 patients and 1702 THA surgeries were included in the final meta-analysis [Figure 1].

### Study characteristics

All studies were prospective RCTs. All the studies described balanced patient baseline characteristics, attempted a minimum follow-up of more than 24 months and specified postoperative care. All selected studies in our meta-analysis are in English and were published between 2005 and 2013. The follow-up period ranged from 2 years to 12.4 years. Each of the included trials presents the baseline balance in age, sex, body mass index. The characteristics of these studies are demonstrated in Table 1.

### Risk of bias

In general, the methodological quality of all the trials was low in bias risk. The adequate randomization technique including a computer-generated number<sup>[17,19]</sup> and a random numbered envelope<sup>[15,16,18,20,21]</sup> was mentioned in seven trials, and another one trial<sup>[14]</sup> did not report how the randomization was performed. Seven trials mentioned allocation concealment<sup>[14-20]</sup> while another one study<sup>[21]</sup> didn't describe it clearly. Outcome assessors were blinded in four studies<sup>[14,16,18,19]</sup> while other four studies<sup>[15,17,20,21]</sup> didn't describe it clearly. The detailed risk of bias about methodological quality of the included studies is elaborated and summarized respectively in Figures 2 and 3.

### Meta-analysis results

#### Postoperative hip function

Due to the undetailed information of the hip scores, it was difficult to pool all the results. Harris hip score was the most

**Table 1: Main characteristics of the included studies**

Author	Year	Enrolment period	Country	Patients (hips, n)	Mean age (years)	Male (%)	Follow up (years)	Study design
Kim	2013	2000–2002	Korea	105 (210)	45.3	66.0	12.4	Prospective randomized self control
Lauren	2013	1998–2003	Canada	92 (92)	51.3 vs. 53.6	54.0	5	Randomized controlled trial
Bal	2005	1998–2001	USA	479 (500)	58.0	51.0	2	Randomized controlled trial
Derek	2011	1999–2001	USA	312 (357)	50.4 vs. 54.7	63.9 vs. 57.5	5	Randomized controlled trial
Lombardi	2010	2000	USA	109 (110)	57.0 vs. 60.0	55.0 vs. 53.0	6	Randomized controlled trial
Cai	2012	2008	China	93 (113)	42.1 vs. 42	58.0 vs. 54.0	3.2	Randomized controlled trial
Lewis	2010	1997–1999	Canada	55 (56)	41.5 vs. 42.8	51.0	8	Randomized controlled trial
Hamilton	2010	2003	USA	263 (264)	56.4 vs. 57.3	51.0 vs. 54.0	2.6	Randomized controlled trial

Author	Material design	Manufacturer
Kim	Alumina on alumina VS. alumina on highly cross-linked polyethylene	BILOX-forte, CeramTec, Plochingen, Germany VS Marathon, DePuy, Warsaw, Indiana
Lauren	Alumina on alumina VS. alumina on highly cross-linked polyethylene	Stryker Orthopaedics (Mahwah, New Jersey, USA)
Bal	Alumina on alumina VS. alumina on polyethylene	Encore Medical, L.P.(Austin, Texas)
Derek	Alumina on alumina VS. alumina on uncross-linked ultrahigh molecular weight polyethylene	Smith and Nephew (Memphis, Tenn)
Lombardi	Alumina matrix composite VS. highly cross-linked polyethylene	Biomet, Inc, Warsaw, IN
Cai	Alumina and ultrahigh-molecular-weight polyethylene liner	Link Medical Technology Inc (Hamburg, Germany)
Lewis	Alumina and ultrahigh-molecular-weight polyethylene liner	Wright Medical Technology Inc (Wright Medical Technology Inc, Arlington, TN)
Hamilton	Delta ceramic-on-ceramic with a Delta ceramic on highly cross-linked polyethylene	BILOX® Delta; CeramTec AG, Plochingen, Germany

utilized in six studies.<sup>[14-18,21]</sup> Western Ontario and McMaster Universities Arthritis Index score was adopted in another study,<sup>[19]</sup> and one study adopted St. Michael's Hip Score.<sup>[20]</sup> All the studies demonstrated no significance between COC and COP except one study<sup>[15]</sup> that demonstrated flexion improved significantly in the COC group compared with the COP group. Another study<sup>[20]</sup> demonstrated that the increase in functional score between the preoperative and postoperative periods was significantly greater for the COC group as compared with the COP group; however, there was no significant difference between the two bearing groups in mean functional score at the latest follow-up.

### Prosthesis loosening

Seven studies reported radiographic evaluation of the hip and six studies reported loosening of the prosthesis. Loosening was defined as a complete radiolucent line of all the zones or migration of the prosthesis. The meta-analysis reveals no statistically significant difference in loosening rate between COC and COP group ( $RR = 1.13$ , 95%  $CI$ : 0.48–2.65;  $P = 0.79$ ) [Figure 4].

### Prosthesis fracture

One of the defects of the COC prosthesis is a prosthesis fracture. Five studies reported the prosthesis fracture. Unsurprisingly, the meta-analysis shows that the COC has a significant higher rate of fracture than the COP ( $RR = 4.46$ , 95%  $CI$ : 1.16–17.25;  $P = 0.03$ ) [Figure 5].

### Squeaking sound

Three documented audible noise of the hip. The meta-analysis results demonstrates that the squeaking sound in COC group is significantly higher than the COP group ( $RR = 14.73$ , 95%

$CI$ : 2.81–77.17;  $P = 0.001$ ) [Figure 6].

### Dislocation

All the eight studies reported dislocation cases. The dislocation rates in COC group seemed a little lower but it didn't reach a statistical significant difference ( $RR = 0.73$ , 95%  $CI$ : 0.44–1.19;  $P = 0.21$ ) [Figure 7].

### Revision

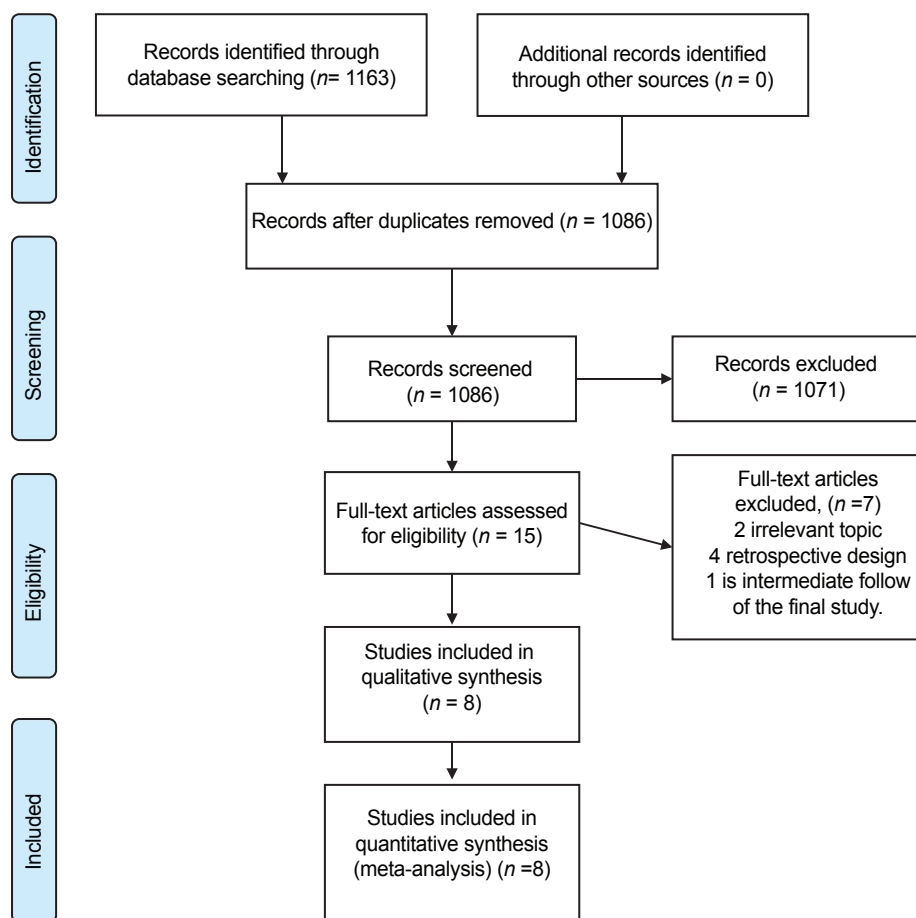
Seven studies reported revision cases. The follow-up time was between 2.0–12.4 years. The causes included hip instability, component loose, recurrent dislocation, deep infection, leg-length discrepancy, prosthesis fracture. The overall revision rate between the groups was similar ( $RR = 0.99$ , 95%  $CI$ : 0.54–1.83;  $P = 0.98$ ) [Figure 8].

### Osteolysis

Four studies reported osteolysis cases. Radiographs were assessed for osteolysis and lucent lines > 1 mm using the zones of DeLee and Charnley<sup>[22]</sup> and Gruen *et al.*<sup>[23]</sup> The meta-analysis results demonstrated a little higher osteolysis rate in the COP group ( $RR = 0.39$ , 95%  $CI$ : 0.10–1.56), but didn't reach a significant statistical difference ( $P = 0.18$ ) [Figure 9].

### Wear rate

Only three studies reported results of wear rate. Amanatullah *et al.*<sup>[16]</sup> compared alumina on alumina versus alumina on uncross-linked ultrahigh molecular weight PE at a follow-up of 5 years. In the ceramic-ceramic group, the mean linear wear rate was  $30.5 \pm 7.0 \mu\text{m}/\text{year}$ , and the mean volumetric wear rate was  $21.5 \pm 4.5 \text{ mm}^3/\text{year}$ . In the ceramic-PE group, the mean linear wear rate was  $218.2 \pm 13.7 \mu\text{m}/\text{year}$ , and the mean volumetric wear rate was  $136.2 \pm 8.5 \text{ mm}^3/\text{year}$ . The increase in



**Figure 1:** Flow diagram.

mean linear and volumetric wear rates in the ceramic-PE group was statistically significant ( $P < 0.001$ ). Kim *et al.*<sup>[18]</sup> compared alumina on alumina versus alumina on highly cross-linked PE for an average of 12.4 years. The mean total amount of highly cross-linked PE linear penetration was  $0.337 \pm 0.315$  mm, and the mean annual penetration rate was  $0.031 \pm 0.004$  mm/year while the COC weren't detectable. Lewis *et al.*<sup>[20]</sup> compared alumina on alumina and alumina on ultrahigh-molecular-weight PE liner. There was a statistically significant difference in total wear between the two bearing groups ( $P < 0.001$ ). The annual wear rate is 0.02 mm for the COC group compared to 0.11 mm/year for the COP group. As the method was variable among the studies, we didn't pool the data. However, all the three studies favor the COC and demonstrate a significant lower wear rates.

### Grading of Recommendations Assessment, Development and Evaluation system assessment

A summary of our results and the strength of evidence assessed through GRADE system are shown in W10 [Figure 10]. The strength of evidence was high for prosthesis fracture, dislocation, osteolysis, but the evidence for radiolucent line or loosening, hip noise, revision was graded as moderate to following reasons: (1) Standard criteria assessing the radiolucent line or loosening was difficult to interpret, and most studies were supported by the manufacturer, this would cause publication bias. (2) Audible

squeaking sound is a subjective parameter without standard criteria for diagnosis.

### DISCUSSION

Although conventional ultra-high molecular weight PE has achieved great success as a bearing surface for THA, osteolysis caused by the wear debris has become one of the leading causes of failure and reoperation. As an alternative to conventional PE bearings, metal on metal, metal or ceramic on highly cross-linked PE, and COC have become popular in the past years. Ceramic bearings are attractive because of hardness and scratch resistance, thus have far-reduced volumetric wear debris in comparison with other types of bearings. However, the higher cost, the squeaking sound, and the prosthesis fracture make the choice controversial. So we conducted the meta-analysis to compare the COC with the COP in clinical, complications and revision rates.

As for the postoperative hip function, most of the studies applied the Harris hip score. However, the mean and the SD of the data were not given to pool all the data. Most studies demonstrated no significant difference between the two bearing surfaces. Loosening of the prosthesis may be caused by the failed ingrowth of the bone into the surface

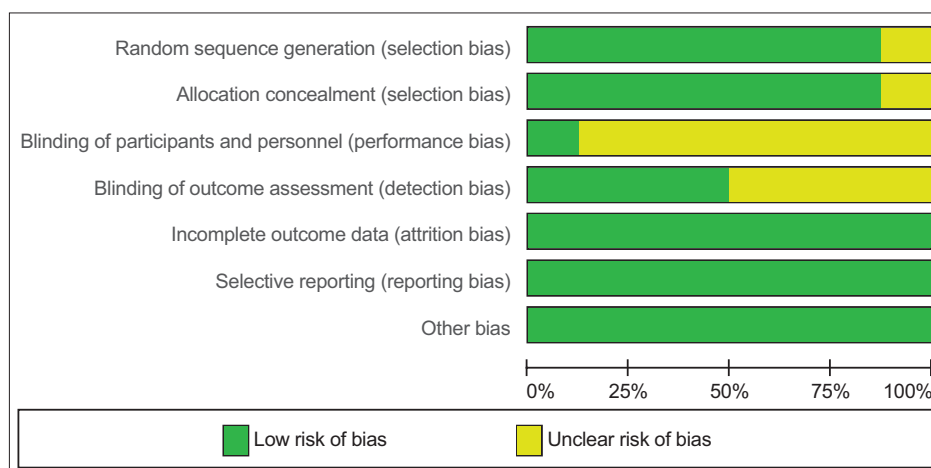
	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bal 2005	?	+	?	+	+	+	+
Cai 2012	+	+	?	?	+	+	+
Derek 2011	+	+	?	+	+	+	+
Hamilton 2010	+	+	?	?	+	+	+
Kim 2013	+	+	?	+	+	+	+
Lauren 2013	+	+	?	+	+	+	+
Lewis 2010	+	+	+	?	+	+	+
Lombardi 2010	+	?	?	?	+	+	+

**Figure 2:** Quality assessment of risk of bias summary in included studies.

of the component. Our meta-analysis reveals no differences between the two bearing couples. This can be easily understood, as both bearing couples have achieved relatively good clinical result in the midterm period.

Limitations of the COC bearing couples include the risk of prosthesis fracture and squeaking, which are quite rare in the conventional polyethylene bearing couples. Squeaking in COC bearings was first reported by Charnley in 1982<sup>[24]</sup> and attracted widespread attention from the orthopedic community in the late 2000s.<sup>[25]</sup> The meta-analysis reveals a quite significant higher rate of fracture of the prosthesis and hip noises. However, the fourth-generation alumina composite ceramics have further reduced risk of fracture to 0.002% by introducing zirconium particles and strontium oxide platelets, which help to prevent the initiation and propagation of cracks.<sup>[26]</sup>

The dislocation rate was similar in the meta-analysis. Concerns about a higher dislocation rate of COC due to limited availability of options for neck length and the liner have been noted. One review<sup>[27]</sup> compared the differences in forces required to dislocate THRs *in vitro* and found no difference in stability between different bearing surfaces if the components position was good. The ceramic bearing surfaces allows the use of larger head sizes and is more often implanted in younger patients, this may account for the finding that overall revision for dislocation is not significantly higher than other surfaces. However, in the late dislocation cases, the PE may become unstable as the liner wear becomes severe. Hernigou *et al.*<sup>[28]</sup> retrospectively reviewed One hundred 26 patients (252 hips) with bilateral THA (one COC and the contralateral COP) at a minimum of 27 years. COC bearing couples decreased the cumulative risk of dislocation as compared with COP bearing couples. The author thought that the reasons for the lower rate of dislocation with COC bearings were likely related to the different histology of the capsule of the hips with the two



**Figure 3:** Risk of bias graph.

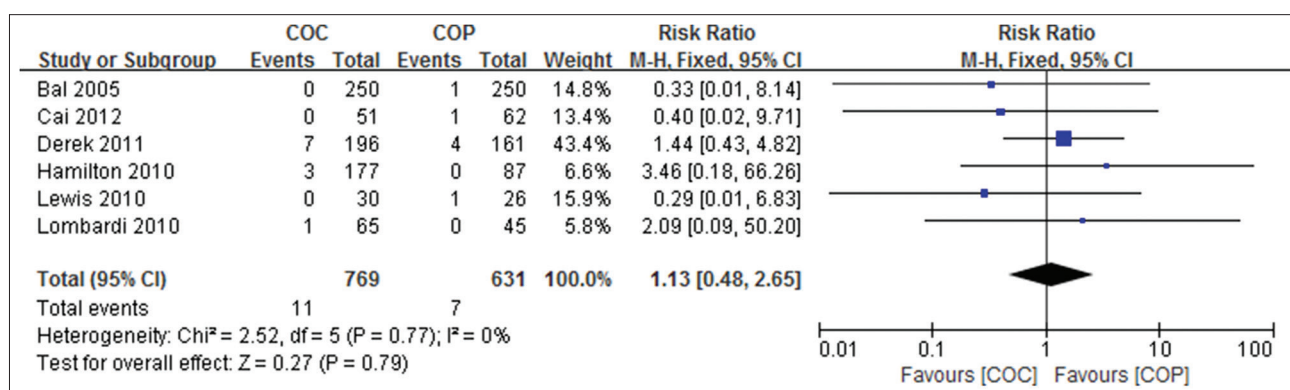


Figure 4: Forest plot of relative risk with confidence intervals for prosthesis loosening.

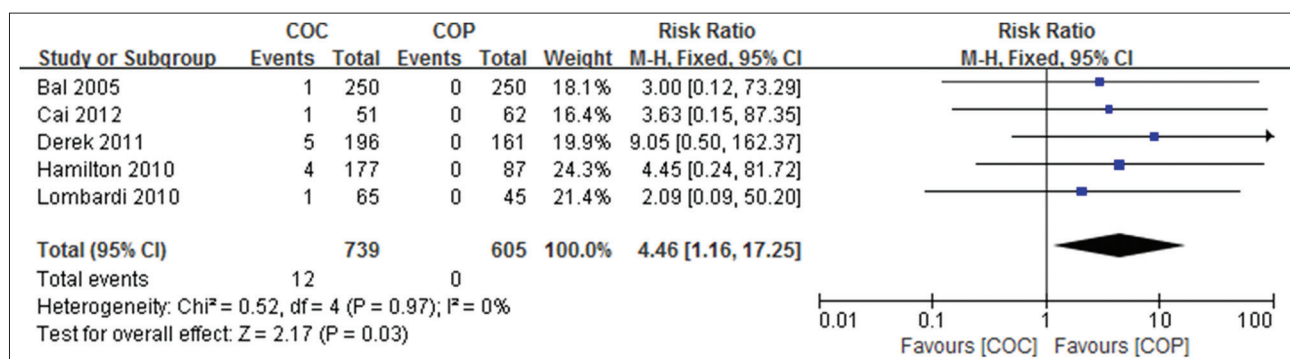


Figure 5: Forest plot of relative risk with confidence intervals for prostheses fracture.

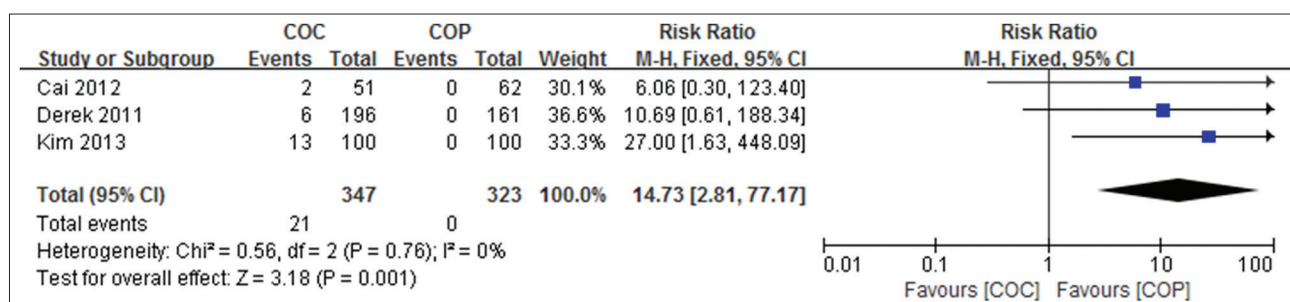


Figure 6: Forest plot of relative risk with confidence intervals for hip noise.

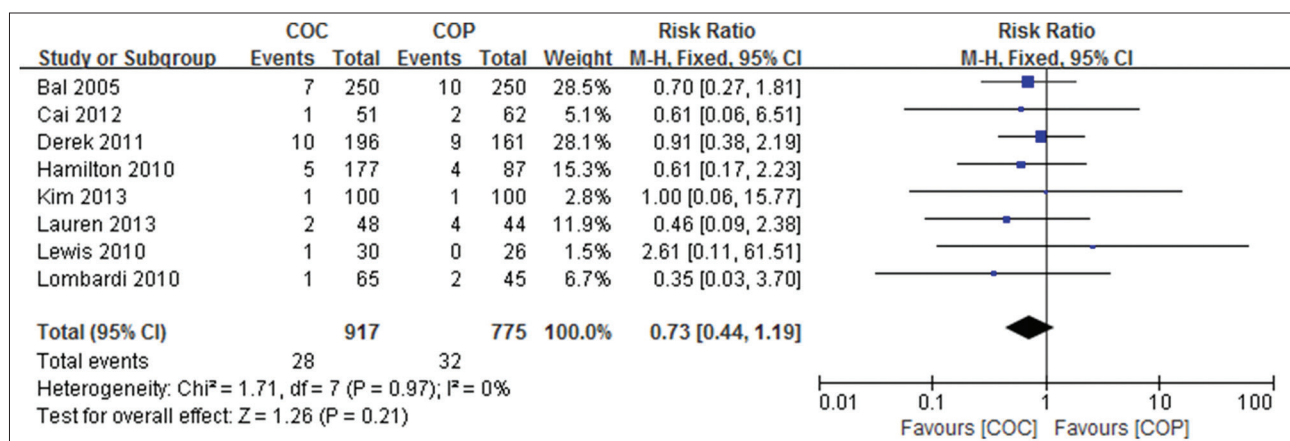


Figure 7: Forest plot of relative risk with confidence intervals for hip dislocation.

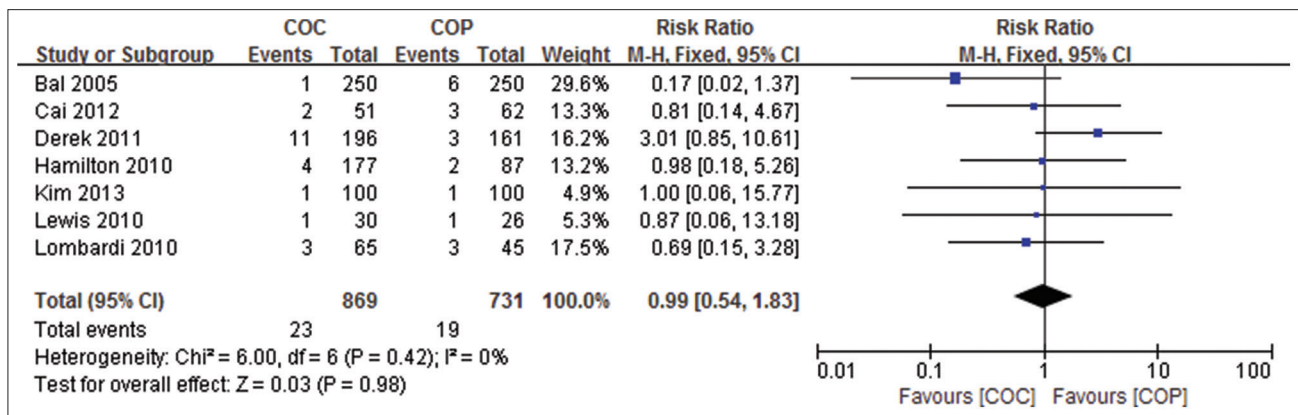


Figure 8: Forest plot of relative risk with confidence intervals for revision.

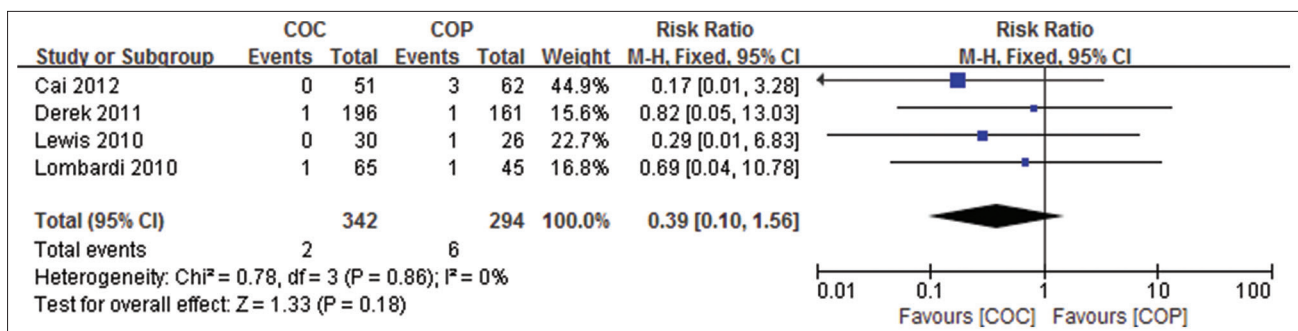


Figure 9: Forest plot of relative risk with confidence intervals for osteolysis.

bearing couples (fibrous and thick with COC; thin and more elastic with PE cups), which was a result of inflammatory reaction to wear debris.

The overall revision rates between the two groups were similar, as the revision may be caused by multiple etiologies. The most seen were hip instability and liner fracture. As the follow-up was not long enough, the revision of the wearing of the PE liner maybe not obvious. Wear-related failure is the most common reason for revision in many published series and joint arthroplasty registries and is significant for young patients who have long life expectancies and place high physical demands on their THRs. Epinette and Manley<sup>[29]</sup> compared survivorship in a cohort of 412 patients (447 hips) who received COC bearings with a cohort of 216 patients (228 hips) with ceramic on highly cross-linked PE bearings for a minimum follow-up of 10 years and found no significant difference in survivorship between cohorts. In a retrospective study of mean follow-up of 11.5 years, four bearing couples of the same acetabular and femoral component were compared. The survival for prosthesis with revision for any reason at 10 years was 98.1% for COP and 95.6% for COC.<sup>[30]</sup>

Osteolysis was most probably caused by the wear debris, and the meta-analysis results showed a higher frequency of osteolysis in the COP group. However, only four studies reported osteolysis, and this limited series did not show statistical significance. Hernigou *et al.*<sup>[31]</sup> investigated wear

and osteolysis on 28 bilateral arthroplasties (one COC and the contralateral COP) of patients who had survived 20 years without revision and without loosening of either hip and found the surface and the volume of osteolysis were consistently higher on the side with the COP bearing couple.

The highly cross-linked PE has been introduced to reduce the volumetric wear of ultra-high molecular weight PE with reported reductions in volumetric wear ranging between 73% and 87%.<sup>[32]</sup> Johanson *et al.*<sup>[33]</sup> conducted a randomized study comparing conventional and cross-linked PE bearings. He found significantly lower linear penetration and three-dimensional wear with use of the highly cross-linked PE bearings than with the use of the conventional PE bearings. In our meta-analysis and systemic review, three studies compared the wear rate. Two studies used the ultrahigh molecular weight PE and one study used the highly cross-linked PE. All demonstrated lower wear rate of the COC group. One study compared the properties of wear debris between COC and COP total hip prostheses. The rate of particle production is significantly lower in the COC group than in the COP group.<sup>[34]</sup> However, more studies are needed to compare the modern ceramic on highly cross-linked PE and COC in wear performances.

The GRADE recommended by The Cochrane Collaboration provides a system for rating quality of evidence and strength of recommendations that is explicit, comprehensive, transparent, and pragmatic and is increasingly being adopted

## Ceramic on ceramic versus ceramic on polyethylene for total hip arthroplasty

Patient or population: patients with total hip arthroplasty

Settings: Outpatient

Intervention: Ceramic on ceramic versus ceramic on polyethylene

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Ceramic on ceramic versus ceramic on polyethylene				
Radiolucent line or loosening complete line or migration Follow-up: 2–8 years	Study population		$RR = 1.13 (0.48-2.65)$	1400 (6 studies)	⊕⊕⊕⊖-Moderate <sup>‡</sup>	
	11 per 1000	13 per 1000 (5–29)				
	Moderate					
Prosthesis fracture intra and postoperative prosthesis fracture Follow-up: 2–6 years	Study population		$RR = 4.46 (1.16-17.25)$	1344 (5 studies)	⊕⊕⊕⊕-High	
	0 per 1000	0 per 1000 (0–0)				
	Moderate					
Hip noise Patients report Follow-up: 3.2–12 years	Study population		$RR = 14.73 (2.81-77.17)$	670 (3 studies)	⊕⊕⊕⊖-Moderate <sup>‡</sup>	
	0 per 1000	0 per 1000 (0–0)				
	Moderate					
Dislocation Radiology Follow-up: 2–12.4 years	Study population		$RR = 0.73 (0.44-1.19)$	1692 (8 studies)	⊕⊕⊕⊕-High	
	41 per 1000	30 per 1000 (18–49)				
	Moderate					
Revision Revision surgery performed Follow-up: 2–12.4 years	Study population		$RR = 0.99 (0.54-1.83)$	1600 (7 studies)	⊕⊕⊕⊖-Moderate <sup>‡</sup>	
	26 per 1000	26 per 1000 (14–47)				
	Moderate					
Osteolysis Radiology Follow-up: 3.2–8 years	Study population		$RR = 0.39 (0.10-1.56)$	636 (4 studies)	⊕⊕⊕⊕-High	
	20 per 1000	8 per 1000 (2–31)				
	Moderate					
		30 per 1000	12 per 1000 (3–45)			

\*The basis for the assumed risk (e.g., the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

<sup>‡</sup>Some were supported by the manufacturer, <sup>§</sup>Patients' reports were subjective. GRADE working group grades of evidence. High quality: Further research is very unlikely to change our confidence in the estimate of effect; Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; Very low quality: We are very uncertain about the estimate. CI: Confidence interval; RR: Risk ratio; GRADE: Grading of Recommendations Assessment, Development and Evaluation.

**Figure 10:** Summary of finds.

by organizations worldwide. In this meta-analysis, we adopted the GRADE system to evaluate our results, which made our results more objective to interpret.

To our concern, this is the first meta-analysis comparing of the COC and COP bearing couple in THA. First, this meta-analysis adopted more strict inclusion criteria. Quasi-RCT and non-RCTs were strictly excluded in this study in order to guarantee the reliability of results. Second, strict strategy was used to assess the methodological quality of the included studies. All the included studies were of highly qualified methodology according to the quality assessment system, which contributes to the strength of conclusions drawn from the meta-analysis. Third, GRADE system was adopted for the assessment of the quality of evidences so as to better guide the clinical practice better.

Despite these advantages, some limitations are still recognized. First, the number of trials included in the study is relatively small, and it is difficult to conduct funnel plots to assess the publication bias. Second, various types of prostheses may bring related bias. Third, since the outcome parameters in different trials were different, it is difficult to pool all of the parameters such as hip function and wear rate. Lastly, only short and middle term follow-up data are available and long term follow-up results still need unavailable.

In summary, our study, as the meta-analysis composed only of RCTs, compared COC and COP in THA. Our results suggested that COC has better wear resistance, lower osteolysis rate but higher fracture rate and the hip noise. The loosening, dislocation rate, revision rate were comparable



between the two bearing couples. According to GRADE system assessment, the strength of evidence was high for a prosthesis fracture, dislocation, osteolysis, and moderate for radiolucent line or loosening, hip noise, and revision. Multicenter RCTs with large samples and more than 10 years follow-up are still needed in the future to verify our results.

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