Int J Clin Exp Med 2017;10(1):59-68
www.ijcem.com /ISSN:1940-5901/IJCEM0036883

Review Article

Compare the revision rate of metal-on-metal and metal-on-polyethylene for total hip replacement: a meta-analysis

Liang Zhang, Dongmei Bao, Zhirong Chen, Peng Li, Haohui Guo, Kening Song, Zhihui Gao, Shuai Zhang, Qunhua Jin

Department of Orthoped, General Hospital, Ningxia Medical University, Yinchuan, Ningxia, China

Received July 29, 2016; Accepted October 19, 2016; Epub January 15, 2017; Published January 30, 2017

Abstract: Total hip replacement (THA) has been one of the most common and reliable surgical operations in 20th Century. The purpose of THA is to provide a joint that is without pain, stability, mobile and durable. Metal-on-metal total hip arthroplasty (MOM-THA) is similar to metal-on-polyethylene (MOP-THA) in function, but there are still some differences in tribology and biological interactions. We performed a meta-analysis to compare revision rate outcomes of MOM-THA and MOP-THA. We performed a systematic review of English articles about MOM-THA and MOP-THA from PubMed, Web of Science and Embase. In THA, MOM bearings compared with MOP bearings in revision rate based on relative risks (RR) using a random effect model or fixed effect model. Study was included in this review if it was: (1) study population is primary THA; (2) the comparison between MOM-THA and MOP-THA; (3) the clinical outcome include the revision rate; (4) with a follow-up duration of at least 1 years. 18 articles was included, six RCTs and twelve cohort study, with 135190 surgeries in the MOM-THA group and 375827 surgeries in the MOP-THA group. The MOP-THA group had a significant lower incidence of revision (RR: 1.22, 95% CI: 1.05-1.43, P: 0.001, I^2: 85.2%) compared with the MOM-THA group. In the subgroup analysis, there was no significant difference of revision rate between MOM-THA group and MOP-THA group in mixed head size (RR: 0.99, 95% CI: 0.60-1.63, P: 0.270, I^2: 22.7%); the prospective study (RR: 1.00, 95% CI: 0.87-1.15, P: 0.001, I^2: 68.3%); the follow-up time ≤3 years (RR: 1.30, 95% CI: 0.90-1.88, P: 0.001, I^2: 81.7%); RCT study (RR: 2.01, 95% CI: 0.70-5.81, P: 0.756, I^2: 0.0%). Compared with MOP-THA group, the MOM-THA group has a little higher revision rate (RR: 1.22, 95% CI: 1.05-1.43, P: 0.001, I^2: 85.2%). There still need larger sample size, more center study to analysis the revision rate of MOM-THA and MOP-THA.

Keywords: Metal-on-metal, metal-on-polyethylene, hip replacement arthroplasty, meta-analysis

Introduction

By 2030, the demand for primary total hip arthroplasties (THA) is estimated to grow by 174% to 572000 in the United States [1]. Metal-on-polyethylene (MOP) bearings have a long history of use in THA [2], but the major problem is periprosthetic osteolysis caused by wear debris released from the bearing surface [3]. In 1995, the international congress of bone and joint surgeons prompted that metal-on-metal (MOM) bearing could be used in hip arthroplasties. Compared with MOP, MOM still has significantly different in tribology and biological interactions. MOM articulations have the good results of hip resurfacing, low metal ion levels, better movement range, reduced dislocation rate and improved wear properties in the long-term follow-up [4-8]. The rates of survival were reported from 92% to 100% at 5 years, 82% to 100% at 10 years [9-11].

Revision of THA may cause by instability, osteolysis, loosening, wear, infection and so on [12]. The most common indications for MOM hip revision were adverse local tissue reaction, the acetabular component aseptic loosening, persistent groin pain and infection. This meta-analysis aimed to evaluate the revision rate of MOM-THA and MOP-THA based on the results of published research.

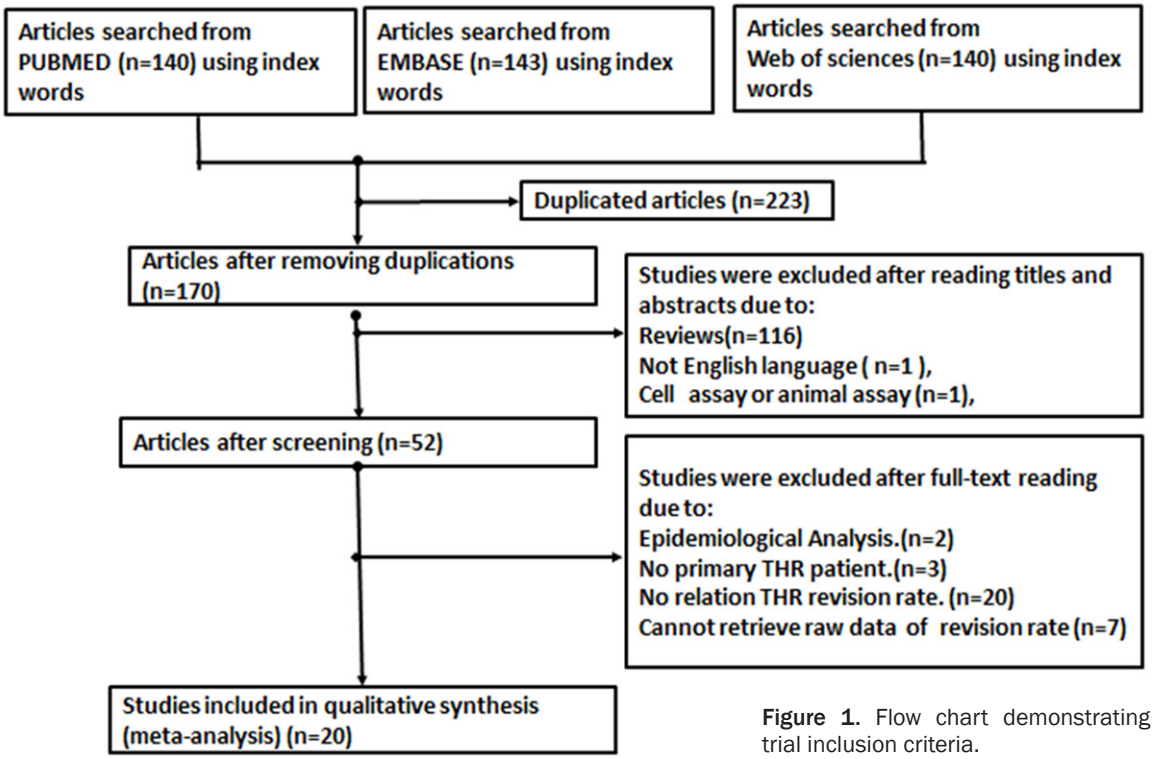

Figure 1. Flow chart demonstrating trial inclusion criteria.

Materials and methods

Search strategy

We conducted a meta-analysis of all English articles identified from Pubmed (by the end of March 23, 2016), Web of Science (by the end of March 23, 2016), Embase (by the end of March 23, 2016). The following key words in combination with Boolean operators: "Metal on Metal", "MOM", "metal-on-polyethylene", "MOP", "hip arthroplasty", "Hip Replacement Arthroplasty", and "Hip Prosthesis Implantation". Related articles and reference lists were searched to avoid any omissions.

The entire search was performed independently by two authors; both of them were blinded to the basic information of publication such as the journal, author, institution, and data and so on. When has a disagreements, a third author was involved to save the problem.

Eligibility criteria and exclusion criteria

A study was included in the analysis if it was: (1) study population is primary THA; (2) the compare between MOM-THA and MOP-THA; (3) the clinical outcome include the revision rate; (4) with a follow-up duration of at least 1 years. A study was excluded in the analysis if it was: (1) review, systematic review, meeting, report and others non-treatise study; (2) animal experiments; (3) the single study of MOM-THA or MOP-THA; (4) the population without THA; (5) unable to retrieve data. Two authors independently assessed the potentially eligible articles, a third author was involved when has any disagreements.

Data extraction

Two investigators independently extracted basic data from the each articles including the following information: year of publication, authors, the country of population, the design of study, randomized, mean age, the percentage of male, No. of patient (MOM/MOP), the years of follow-up and so on. The two reviewers also recorded the outcome of revision rate in the MOM-THA group and MOP-THA group. When finished the data extracted, a third investigator was involved to check.

Data analysis

All the meta-analyses were performed in the STATA software (version 10.0 StataCorp, Texas,

Table 1. Characteristics of the eighteen included studies

Study	Population	The design of study	Randomized	The follow-up time	Male (percentage)	Head size		MOM-THA		MOP-THA	
						MoM-THA	MoP-THA	Total	Revision	Total	Revision
C.A. Engh (2014)	Canada	Prospective	Y (RCT)	5 years	0.62	28 mm-36 mm	28 mm	68	5	37	1
Kevin L. Ong (2013)	American	Prospective	NO	5.25 years	0.38	all	all	55141	1897	165423	5310
Sandrine Colas (2015)	French	Retrospective	-	3 years	0.43	all	all	4381	168	33983	993
Colin T. Penrose BS (2016)	England	Retrospective	-	2 years	0.34	all	all	377	74	510	118
Simon S. Jameson (2003)	England	Retrospective	-	3 years	0.43	all	all	9736	211	9242	113
Sammy A. Hanna (2012)	England	Prospective	Y (RCT)	3 years	0.22	44 mm-54 mm	28 mm-32 mm	27	0	22	0
Wierd P. Zijlstra (2009)	Netherlands	Prospective	Y (RCT)	5.6 years	0.21	28 MM	28 mm	102	3	98	1
Michael Jacobs (2004)	American	Prospective	Y (RCT)	3.7 years	0.57	28 mm	28 mm	95	1	76	1
F. Cozzolino (2002)	Italy	Retrospective	-	4 years	0.33	28 mm	28 mm	65	0	70	0
Kevin J. Bozic (2012)	American	Prospective	-	4 years	0.38	all	all	49646	1460	93929	2677
A. Malviya (2011)	England	Prospective	Y (RCT)	4 years	0.42	38-54 mm	28 mm	48	2	48	2
Der-Chen T. Huang (2013)	St Paul	Retrospective	NO	8.5 years	0.46	all	all	1045	73	1257	29
Ingrid Milosev (2012)	Slovenia	Prospective	NO	10.5 years	0.24	28 mm	28 mm	55	6	161	3
Rocco P. Pitto (2015)	New Zealand	Retrospective	NO	7 years	0.47	all	all	5910	48	53331	621
Matevž Topolovec (2014)	Slovenia	Retrospective	NO	11.5 years	0.72	28 mm	28 mm	322	35	587	23
J. Mokka (2013)	Finland	Prospective	NO	8 years	0.45	38 mm and above	38 mm and above	8059	202	16978	555
T.B. Hansen (2013)	Denmark	Retrospective	NO	5 years	-	-	-	78	20	40	8
Wierd P. Zijlstra (2013)	Netherlands	Prospective	Y (RCT)	1 year	-	48 mm	28 mm	35	3	35	0

Note: - : In this paper, the authors did not mention. RCT: randomized controlled trail.

Table 2. Meta-analysis of the revision rate between MoM THA and MoP THA

Study	RR	Lower Limit	Upper Limit	P (RR)	I^2	P (Heterogeneity)	P (Begg's Test)	P (Egger's test)
Revision rate	1.236	1.050	1.455	0.011	85.2%	0.000	0.685	0.171

Table 3. Subgroup of Meta-analysis of the difference revision rate between MOM-THA and MOP-THA

Study	Subgroup	No. of study	No. of MOM	No. of MOP	RR	Lower Limit	Upper Limit	P (RR)	I^2	P (Heterogeneity)
Randomized	Yes	6	375	316	2.015	0.698	5.812	0.756	0.0%	0.195
	No	12	134815	375511	1.224	1.036	1.445	0.000	89.8%	0.017
The design of study	Prospective	10	113276	276807	0.998	0.868	1.148	0.001	68.3%	0.980
	Retrospective	8	21914	99020	1.469	1.007	2.143	0.000	89.6%	0.046
Head size	Mix	6	8315	17160	0.991	0.601	1.633	0.270	22.7%	0.972
	All	7	126236	357675	1.193	1.012	1.406	0.000	90.2%	0.036
	28 mm	5	639	992	3.142	1.927	5.123	0.584	0.0%	0.000
The follow-up time	≤3 years	5	14556	43792	1.300	0.897	1.885	0.001	81.7%	0.166
	>3 years and ≤6 years	8	105243	259721	1.059	1.016	1.103	0.837	0.0%	0.007
	>6 years	5	15391	72314	1.727	0.874	3.415	0.000	93.8%	0.116

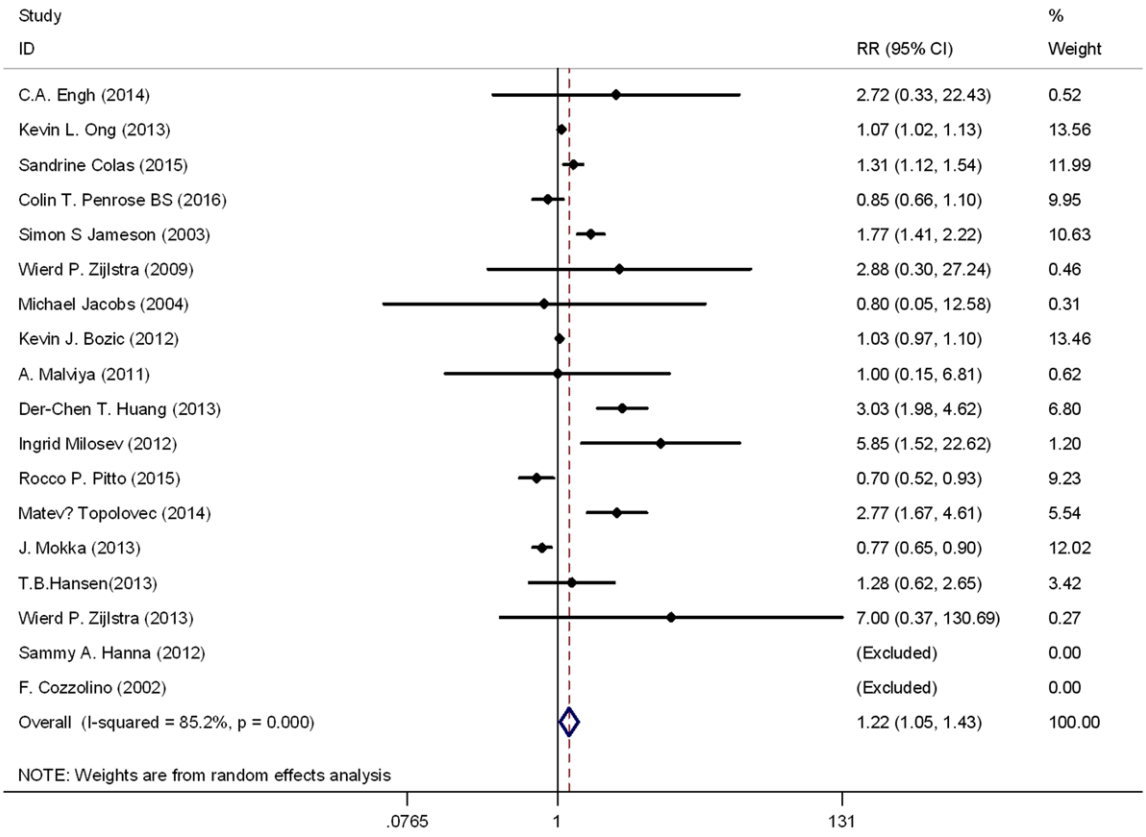

Figure 2. Forest plot of the revision rate.

USA). We analyzed the revision rate by calculating relative risks (RR), along with 95% confidence intervals (CI). Heterogeneity was assessed by chi-squared and I^2 tests. For the meta-analysis, fixed-effects model and random-effects model were both considered. Choosing which effect model depend on the values of Heterogeneity statistics. When the *P*-value of <

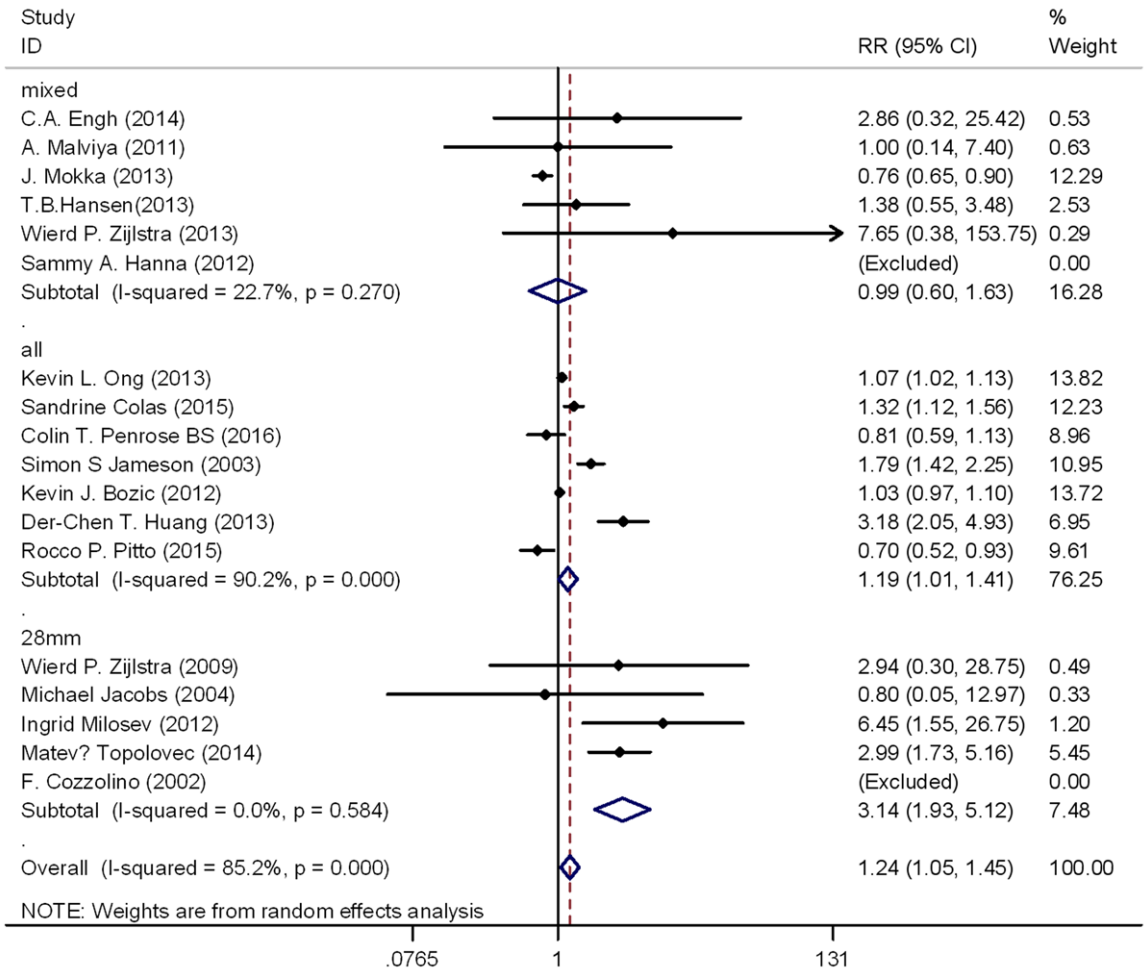

Figure 3. Forest plot of subgroup analysis.

0.01 and I^2 < 30%, we selected fixed-effects model, on the contrary using random-effects model.

Results

Search results

423 articles retrieved by the search strategy, 370 articles were excluded after the first and second screening based on titles or abstracts, and 52 articles need for full-text review. After full-text reading, 34 studies were excluded due to: epidemiological analysis (n=2), no primary THR patient (n=3), no relation THR revision rate (n=20), cannot retrieve raw data of revision rate (n=9). Eighteen studies were included in the qualitative synthesis, 135190 patients in the MOM-THR group, and 375827 patients in the MOP-THR group (**Figure 1**).

Study characteristics

The main characteristics of the eighteen included studies were summarized in **Table 1**. Six [15-20] were randomized controlled trials (RCT), seven [21-27] were not randomized trials, five [28-32] do no mention whether was randomized or not. Ten were prospective study, eight were retrospective study. All the studies provided the No. of patient (MoM/MoP) and the follow-up years (the shortest is 1 year, the longest is 11.5 years). Most studies (n=16) provided the percentage of male. The head size of THA in the eighteen studies was including all the size.

Revision rate

We chose the random-effects model to analysis revision rate (I^2=85.2%, P < 0.001). The res-

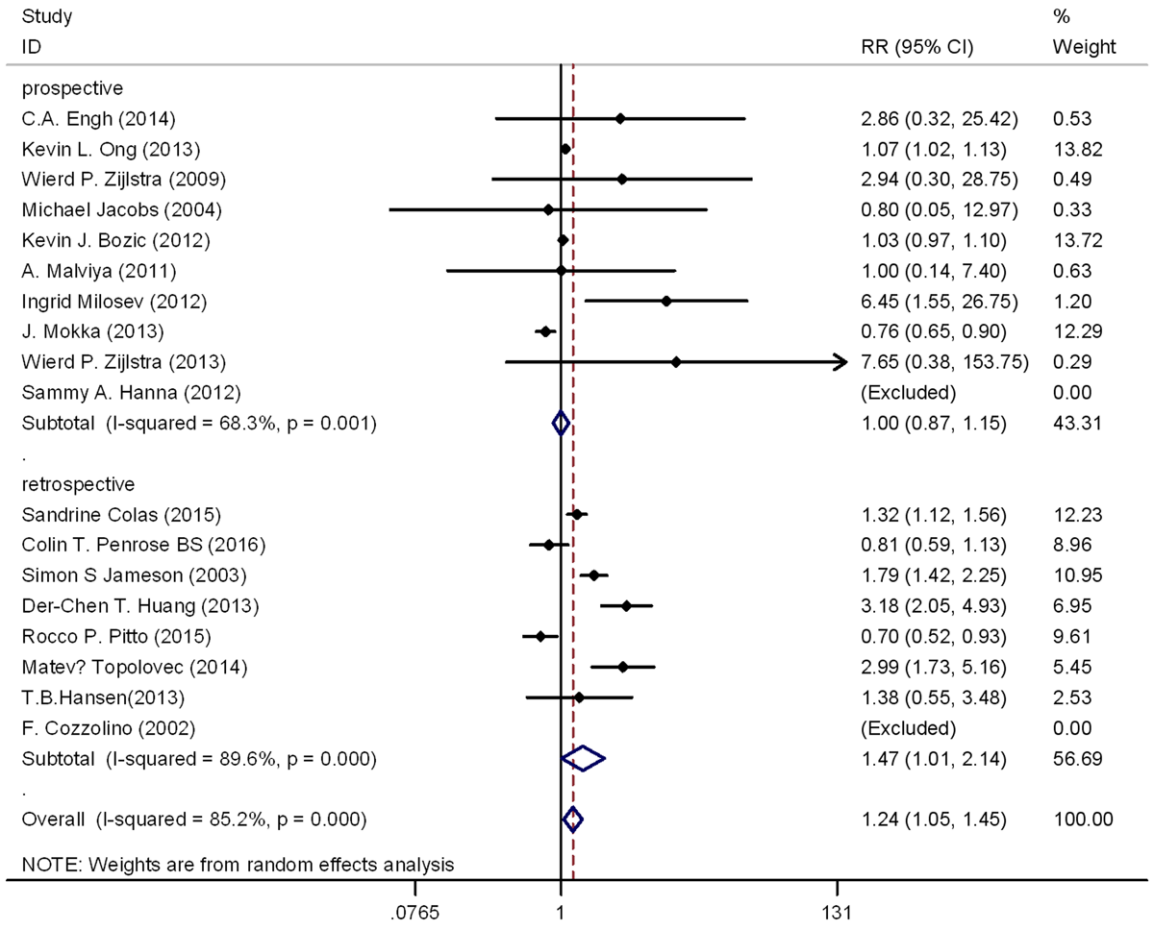

Figure 4. Forest plot of subgroup analysis.

ults show that the revision rate of MOM-THA was significant higher than MOP-THA (RR: 1.22, 95% CI: 1.05-1.43, I^2: 85.2%, P: 0.000) (**Tables 2**, **3**; **Figure 2**). In **Figure 2**, we can found that between the different studies, the RR and 95% CI of revision rate has big variances.

Subgroup analysis

In the subgroup analysis (**Figures 3**-**6**), there were no significant difference of revision rate between MOM-THA group and MOP-THA group in randomized study (RR: 2.01, 95% CI: 0.70-5.81, I^2: 0.0%, P: 0.756), prospective design study (RR: 1.00, 95% CI: 0.87-1.15, I^2: 68.3%, P: 0.001), mix head size study (RR: 0.99, 95% CI: 0.60-1.63, I^2: 22.7%, P: 0.270), the follow-up time ≤3 years (RR: 1.30, 95% CI: 0.90-1.88, I^2: 81.7%, P: 0.001), the follow-up time >6 years (RR: 1.73, 95% CI: 0.87-3.42, I^2: 93.8%, P: 0.000). In the subgroup analysis of no-randomized study (RR: 1.22, 95% CI: 1.05-1.45, I^2: 85.2%, P: 0.000), retrospective design study (RR: 1.47, 95% CI: 1.01-2.14, I^2: 89.6%, P: 0.000), all head size study (RR: 1.19, 95% CI: 1.01-1.41, I^2: 90.2%, P: 0.000), 28 mm head size study (RR: 3.14, 95% CI: 1.93-5.12, I^2: 0.0%, P: 0.584), the follow-up time >3 years and ≤6 years (RR: 1.06, 95% CI: 1.02-1.10, I^2: 0.0%, P: 0.837), pooled analysis shown revision rate of MOM-THA group is significant higher than MOP-THA group.

Discussion

This meta-analysis aimed to explore the variance of revision rate between MOM-THA group and MOP-THA group. The analysis result of eighteen involved studies shown that the revision rate of MOM-THA group was a little higher than MOP-THA group. In the subgroup analysis, we involved the study design, head size and follow-up time to explore the source of heterogeneity. From the forest plot of subgroup analy-

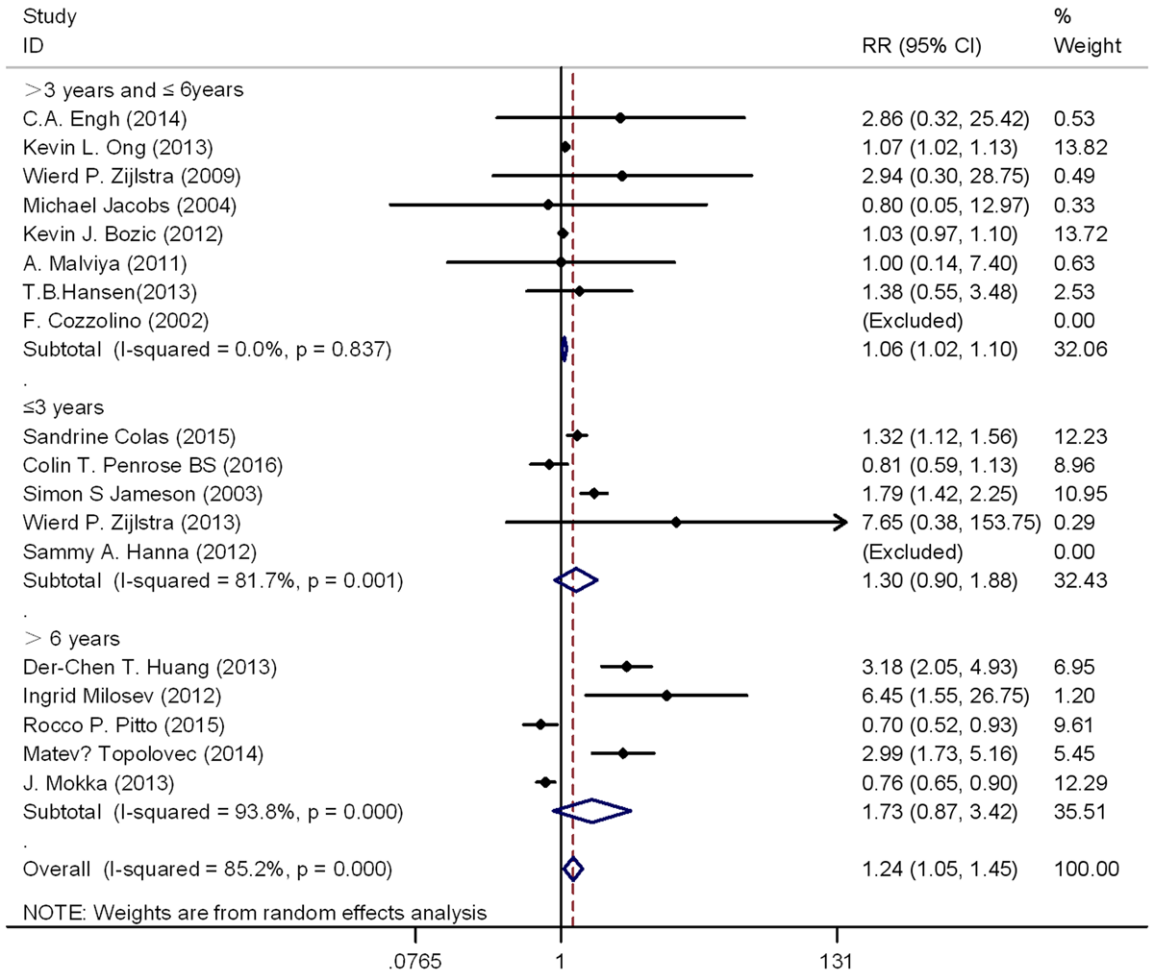

Figure 5. Forest plot of subgroup analysis.

sis, we can know the different design of study (randomized or non, prospective or retrospective), the size of head (28 mm, all, mix) and the duration of follow-up are the source of heterogeneity in the revision rate of patients in the two groups.

We reviewed the previous meta-analyses, and compared the clinical outcomes of MOM-THA and MOP-THA. Pramod [33] B found that there was no statistically significant differences of the functional outcomes as measured by Harris hip scores and radiographic outcomes as measured by radiolucent lines between MOM and conventional THA; However, with the increase complication rate, the greater cost, and the potential for adverse medical consequences associated with MOM-THA, so authors encourage caution with the use of MOM bearing surfaces. Wander [34] indicated that the survival rate of MOM-THA is 90% at a follow-up of ten years, and 370 were revised (3.5%) of 10621 hips with aseptic loosening as the most frequent mode of failure, the long-term effectiveness and safety analysis is needed. Xinhua Qu [35] shown that MOM-THA has no any clinical advantages compared with MOP-THA, the cobalt and chromium ion concentrations were elevated in MOM-THA, the total complication rate was no significant difference in the two groups, so MOM bearings in THA should be used with caution. Si Yin [36] made a network meta-analysis that indicated the similar performance in survivorship among ceramic-on-ceramic, ceramic-on-conventional polyethylene, ceramic-on-highly-cross linked polyethylene, metal-on-high-cross linked polyethylene, and that all have superiority compared with MOM and metal-on-conventional polyethylene. From the above meta-analyses, we found that

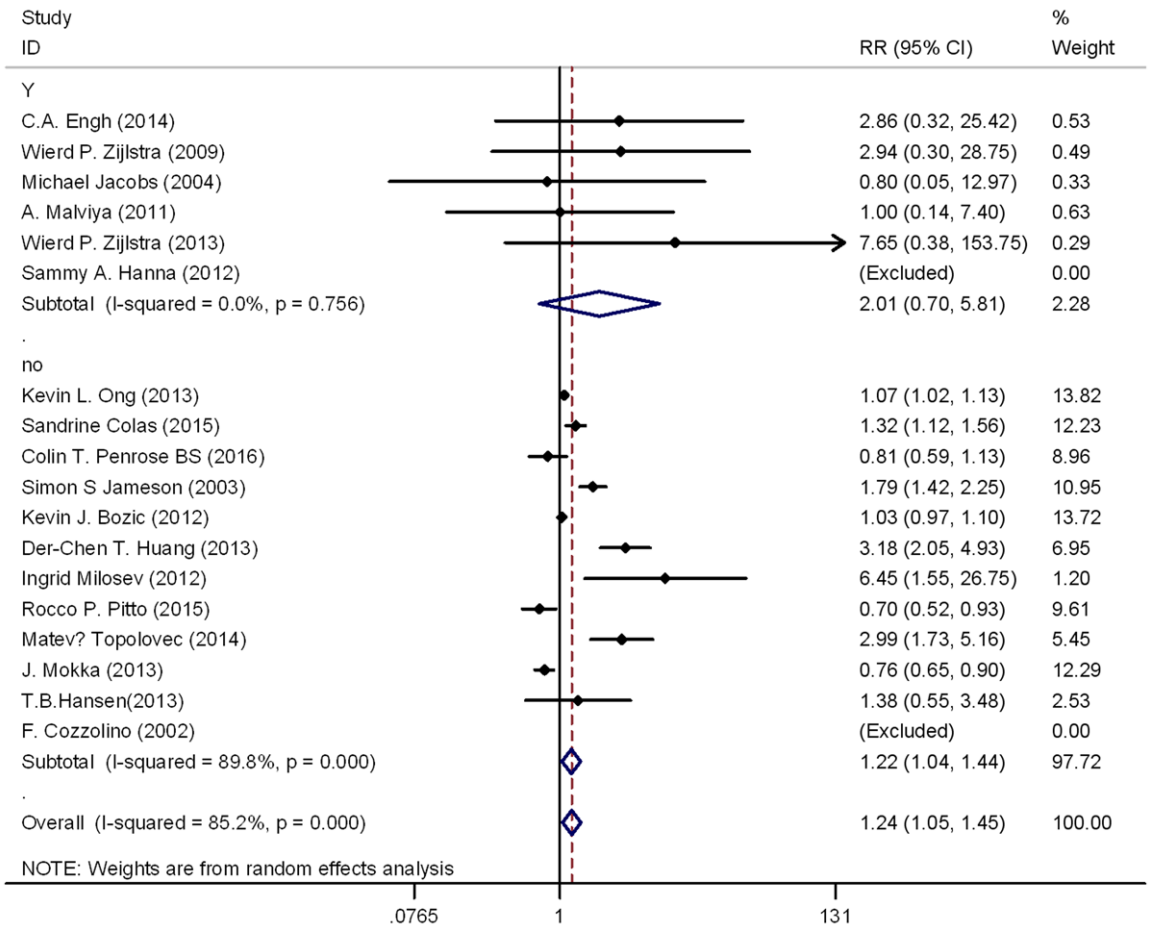

Figure 6. Forest plot of subgroup analysis.

MOM-THA has no significant clinical advantages than MOP-THA.

In our study, the limitations are as follows: (1) only six RCTs were involved, the others twelve articles are not high qualities; (2) the differences in diagnosis and reporting outcomes; (3) the basically information of patients in different studies was inconsistent, and the previous diseases were unavailable; (4) individual patient data can't be get, the meta-analysis used pooled data. For these reasons, we still need more detailed, comprehensive and high statistical quality studies.

In conclusion, we found the revision rate was significant little higher in MOM-THA group, compared with MOP-THA group. There still need larger sample size, multi-centers, high statistical quality, and long-term follow up studies, and we can explore the reasons of revision in the future study. However, patients should be cautions when choose the MOM bearing surfaces.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Qunhua Jin, Department of Orthoped, General Hospital, Ningxia Medical University, Yinchuan 750004, Ningxia, China. Tel: +86-0951-6743581; Fax: +86-0951-4082981; E-mail: qunhuajin@163.com

References

[1] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary, revision hip, knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007; 89: 780-785.

[2] Hallan G, Dybvik E, Furnes O and Havelin LI. Metal-backed acetabular components with conventional polyethylene: a review of 9113 primary components with a follow-up of 20 years. J Bone Joint Surg Br 2010; 92: 196-201.

[3] Maezawa K, Nozawa M and Hirose T. Cobalt and chromium concentrations in patients with

metal-on-metal andother cementless total hip arthroplasty. Arch Orthop Trauma Surg 2002; 122: 283-287.
[4] Treacy RB, McBryde CW, Shears E and Pynsent PB. Birmingham hip resurfacing: a minimum follow-up of ten years. J Bone Joint Surg Br 2011; 93: 27-33.
[5] McMinn DJ, Daniel J, Ziaee H and Pradhan C. Results of the Birmingham Hip Resurfacing dysplasia component in severe acetabular insufficiency: a six- to 9.6-year follow-up. J Bone Joint Surg Br 2008; 90: 715-723.
[6] Clarke MT, Lee PT and Villar RN. Dislocation after total hip replacement in relation to metal-on-metal bearing surfaces. J Bone Joint Surg Br 2003; 85: 650-654.
[7] Berton C, Girard J, Krantz N and Migaud H. The Durom large diameter head acetabular component: early results with a large-diameter metal-on-metal bearing. J Bone Joint Surg Br 2010; 92: 202-208.
[8] Wimmer MA, Fischer A and Büscher R. Wear mechanisms in metal-on-metal bearings: the importance of tribochemical reaction layers. J Orthop Res 2010; 28: 436-443.
[9] Bolland BJ, Culliford DJ, Langton DJ, Millington JP, Arden NK and Latham JM. High failure rates with a large-diameter hybridmetal-on-metal total hip replacement: clinical, radiological and retrieval analysis. J Bone Joint Surg Br 2011; 93: 608-615.
[10] Delaunay CP, Bonnomet F, Clavert P, Laffargue P and Migaud H. THA using metal-on-metal articulation in active patients younger than 50 years. Clin Orthop Relat Res 2008; 466: 340-346.
[11] Mihalko WM, Wimmer MA, Pacione CA, Laurent MP, Murphy RF and Rider C. How have alternative bearings and modularity affected revision rates in total hip arthroplasty? Clin Orthop Relat Res 2014; 472: 3747-3758.
[12] Lawless BM, Healy WL, Sharma S and Iorio R. Outcomes of isolated acetabular revision. Clin Orthop Relat Res 2010; 468: 472-479.
[13] Browne JA, Bechtold CD, Berry DJ, Hanssen AD and Lewallen DG. Failed metal-on-metal hip arthroplasties: a spectrum of clinical presentations and operative findings. Clin Orthop Relat Res 2010; 468: 2313-2320.
[14] Prieto HA, Berbari EF and Sierra RJ. Acute delayed infection: increased risk in failed metal on metal total hip arthroplasty. J Arthroplasty 2014; 29: 1808-1812.
[15] Engh CA, MacDonald SJ, Sritulanondha S, Korczak A, Naudie D and Engh C. Metal ion levels after metal-on-metal total hip arthroplasty a five-year, prospective randomized trial. J Bone Joint Surg Am 2014; 96: 448-455.
[16] Hanna SA, Sewell MD, Sri-Ram K, Miles J, Aston WJ, Pollock RC, Carrington RW and Briggs TW. The effect of femoral head size on functional outcome in primary total hip arthroplasty: a single-blinded randomised controlled trial. Hip Int 2012; 22: 592-597.
[17] Zijlstra WP, Cheung J, Sietsma MS, van Raay JJ and Deutman R. No superiority of cemented metal-on-metal vs metal-on-polyethylene THA at 5-year follow-up. Orthopedics 2009; 32: 479.
[18] Jacobs M, Gorab R, Mattingly D, Trick L and Southworth C. Three- to six-year results with the ultima metal-on-metal hip articulation for primary total hip arthroplasty. J Arthroplasty 2004; 19 Suppl 2: 48-53.
[19] Malviya A, Ramaskandhan JR, Bowman R, Kometa S, Hashmi M, Lingard E and Holland JP. What advantage is there to be gained using large modular metal-on-metal bearings in routine primary hip replacement? J Bone Joint Surg Br 2011; 93: 1602-1609.
[20] Zijlstra WP, van der Veen HC, van den Akker-Scheek I, Zee MJ, Bulstra SK, van Raay JJ. Acetabular bone density and metal ions after metal-on-metal versus metal-on polyethylene total hip arthroplasty; short-term results. Hip Int 2014; 24: 136-43.
[21] Kevin L. Ong, Edmund Lau and Steven MK. Risk of complications, revision, and cancer for metal-on-metal patients in the medicare population. ASTM international, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.
[22] Huang DC, Tatman P, Mehle S, Gioe TJ. Cumulative revision rate is higher in metal-on-metal THA than metal-on-polyethylene THA: analysis of survival in a community registry. Clin Orthop Relat Res 2013; 471: 1920-1925.
[23] Milošev I, Kovač S, Trebše R, Levašič V, Pišot V. Comparison of ten-year survivorship of hip prostheses with use of conventional polyethylene, metal-on-metal, or ceramic-on-ceramic bearings. J Bone Joint Surg Am 2012; 94: 1756-1763.
[24] Pitto RP, Garland M and Sedel L. Are ceramic-on-ceramic bearings in total hip arthroplasty associated with reduced revision risk for late dislocation? Clin Orthop Relat Res 2015; 473: 3790-3795.
[25] Topolovec M and Milošev I. A comparative study of four bearing couples of the same acetabular and femoral component: a mean follow-up of 11.5 years. J Arthroplasty 2014; 29: 176-180.
[26] Mokka J, Mäkelä KT, Virolainen P, Remes V, Pulkkinen P and Eskelinen A. Cementless total hip arthroplasty with large diameter metal-on-metal heads: short-term survivorship of 8059

hips from the finnish arthroplasty register. Scand J Surg 2013; 102: 117-123.
[27] Hansen TB, Dremstrup L and Stilling M. Patients with metal-on-metal articulation in trapeziometacarpal totaljoint arthroplasty may have elevated serum chrome and cobalt. J Hand Surg Eur Vol 2015; 38: 860-865.
[28] Colas S, Collin C, Piriou P and Zureik M. Association between total hip replacement characteristics and 3-year prosthetic survivorship a population-based study. JAMA Surg 2015; 150: 979-988.
[29] Penrose CT, Seyler TM, Wellman SS, Bolognesi MP, Lachiewicz PF. Complications are not increased with acetabular revision of metal-on-metal total hip arthroplasty. Clin Orthop Relat Res 2016; 474: 2134-2142.
[30] Jameson SS, Baker P, Mason J and Rymaszewska M. Independent predictors of failure up to 7.5 years after 35 386 single-brand cementless total hip replacements: a retrospective cohort study using National Joint Registry data. Bone Joint J 2013; 95: 747-757.
[31] Cozzolino F, Mariconda M and Costa L. A comparative study on medium-term results of cementless acetabular components with metal-on-metal and metal-on-polyethylene articulations. J Orthopaed Traumatol 2002; 2:129-133.
[32] Bozic KJ and Edmund CL. Comparative effectiveness of metal-on-metal and metal-on-polyethylene bearings in medicare total hip arthroplasty patients. J Arthroplasty 2012; 27: 8-14.
[33] Voleti PB, Baldwin KD and Lee GC. Metal-on-metal vs conventional total hip arthroplasty a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty 2012; 27: 10-18.
[34] Weegen W, Hoekstra HJ, Sijbesma T and Bos E. Survival of metal-on-metal hip resurfacing arthroplasty: a systematic review of the literature. J Bone Joint Surg Br 2011; 93: 298-306.
[35] Qu XH, Huang X and Dai K. Metal-on-metal or metal-on-polyethylene for total hip arthroplasty: a meta-analysis of prospective randomized studies. Arch Orthop Trauma Surg 2011; 131: 1573-1583.
[36] Yin S, Zhang D, Du H, Du H, Yin Z and Qiu Y. Is there any difference in survivorship of total hip arthroplasty with different bearing surfaces? A systematic review and network meta-analysis. Int J Clin Exp Med 2015; 8: 21871-21885.