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Original Article

Comparison of the two acetabular components in total hip arthroplasty: a meta-analysis

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Abstract: It is controversial that whether tantalum acetabular components have more favorable clinical outcomes for patients receiving primary or revision total hip arthroplasty (THA), compared with titanium acetabular implants. Herein, we performed a meta-analysis to conclusively estimate the difference in the clinical outcomes between tantalum and titanium acetabular components after THA. In this study, we used the Harris hip score (HHS), instability rate, failure rate and the incidence of gaps as indices for clinical outcomes. The Standardized Mean Difference (SMD)/odds ratios (OR) with corresponding 95% confidence interval (CI) for each parameter was calculated. For HHS, there was no significant difference between tantalum and titanium acetabular components for patients after receiving THA (SMD = 0.066, P = 0.799). In terms of the instability rate and failure rate, the results demonstrated that patients in titanium acetabular components group had significantly higher instability rate and failure rate than those in tantalum acetabular implants (instability: OR = 0.454, P < 0.001; failure: OR = 0.448, P = 0.001). With regard to the incidence of gaps, no significant difference was detected between the two groups (OR = 0.403, P = 0.295). In conclusion, our meta-analysis suggests that patients receiving tantalum acetabular components in THA are more likely to have favorable clinical outcomes, compared with those receiving titanium acetabular components.

Keywords: THA, tantalum acetabular components, titanium acetabular components, meta-analysis

Introduction

Total hip arthroplasty (THA), reducing pain and improving function, is highly effective treatment for patients with end-stage arthritis of the hip [1-3]. It has been speculated that the number of individuals in need of THA would increase by over 170% by 2030 [2]. An epidemiological study documented that in England and Wales the number would be in the range of 186,893 to 805,835 for THA in 2030 [4]. THA usually has an extremely high satisfaction rate and a relatively low occurrence rate of complications with a goal to reconstruct suitable offset and maximize impingement-free range of motion [1].

With the increasing number of primary THA procedures, there is accordingly a parallel increased number of revision THA [5]. Several indications are regarded as to be associated with the acetabular revision such as instability, symptomatic aseptic loosening, osteolysis, infection and so on [6]. The uncemented components are used more widely in THA due to better clinical outcomes compared with cement components [6-8]. And the most commonly used uncemented components are made of titanium and tantalum [9]. The titanium acetabular components are beneficial for a large number of patients receiving primary or revision THA [10-12]. The tantalum acetabular implants, with a structure similar to trabecular bone, have property of successful osseointegration [13].

Currently, there is no definitive conclusion about whether tantalum acetabular components have more favorable clinical outcomes for patients receiving primary or revision THA, compared with titanium acetabular implants. A case-control study, published in 2015, was aimed to compare the clinical outcomes of tantalum acetabular components with titanium acetabular implants in THA, and the results inferred that the use of tantalum acetabular implants was associated with lower failure rate and instability rate [9]. However, a retrospective study, performed by Jafari and colleagues, was aimed to explore the clinical outcomes between tantalum and titanium acetabular components in THA, and the data revealed that the tantalum and titanium acetabular components had similar failure rates and instability rates [5]. Herein, in order to comprehensively appraise the difference in the clinical outcomes between tantalum and titanium acetabular components after the primary or revision THA, we attempted to conduct a meta-analysis to assess the difference with Harris hip score (HHS), instability rate, failure rate and the incidence of gaps as indices for clinical outcomes.

Materials and methods

Search strategy

A systematic literature search was performed using a multiple electronic databases including PubMed (1966-2016), EMBASE (1980-2016) and Web of science (1945-2016). The search terms were set as "Tantalum" "Titanium" and "hip arthroplasty". Reference lists of relevant literatures were manually examined for additional articles. The latest date for the literature retrieval was January 12, 2016. Two independent reviewers evaluated the potential literatures, and the disagreements were settled by consensus.

Inclusion and exclusion criteria

Inclusion criteria for eligible studies were as follows: (1) patients receiving the primary or revision THA; (2) patients in one arm receiving tantalum acetabular components, in the other arm receiving titanium acetabular implants; (3) studies reported relevant outcomes post-operation. The exclusion criteria were as follows: (1) patients receiving arthroplasty rather than THA; (2) non-human research; (3) duplicate data or repeat analysis.

Data extraction

After assessing the eligibility of retrieved literatures based on our above inclusion and exclusion criteria, we collected and extracted data elements including: the first author, year of publication, methods to detect the clinical outcomes for patients, acetabular components for control and case groups, the head components, the age of patients, ratio of males and the number of patients in case and control groups.

Statistical analysis

As previous relevant studies, we used HHS, instability rate, failure rate and the incidence of gaps as indices for clinical outcomes [5, 9, 14-19]. For dichotomous outcomes, the odds ratios (OR) and corresponding 95% confidence interval (CI) were calculated as the summary statistics. For continuous outcomes, we calculated the SMD (Standardized Mean Difference) with 95% CI. We used the Chi-square test to evaluate the heterogeneity inter-included studies. The heterogeneity was expressed by I^2 index. The value of I^2 less than 50% represented small heterogeneity, and the Mantel-Haenszel (M-H) fixed-effects model was chosen to calculate the OR with 95% CI, while the Inverse-Variance (I-V) fixed-effects model was adopted for the calculation of SMD and the corresponding 95% CI. If the I^2 was more than 50%, the DerSimonian and Laird (D-L) random-effects model was applied for the calculation of both OR with 95% CI and SMD with 95% CI. The value of P less than 0.05 was judged as statistically significant. All statistical tests were conducted with STATA 12 software (STATA Corp LP, College Station, Texas, United States).

In this meta-analysis, the data in titanium acetabular components group (control) was regarded as reference to calculate the OR/SMD and the corresponding 95% CI. An OR < 1 signified the instability rate, failure rate and the incidence of gaps in control group were higher than those in case group. A SMD < 0 revealed that the HHS in control group was higher than that in case group. We used both the Begg's test and Egger's test to estimate the publication bias in our meta-analysis. The significance level was set at 0.05.

Results

According to the search strategies as described, a total of 203 primary literatures were identified, among which 24 from PubMed, 48 from EMBASE and 131 from Web of science. We eliminated 45 duplications, and 159 literatures were screened for detailed assessment through reading the titles and abstracts. Then, 19 literatures were remained for further evaluation. Finally, 8 literatures were eligible in our meta-analysis after full-text assessment. The flow diagram of literature inclusion and exclusion was displayed as **Figure 1**. The characteristics of retained literatures were listed in **Table 1**.

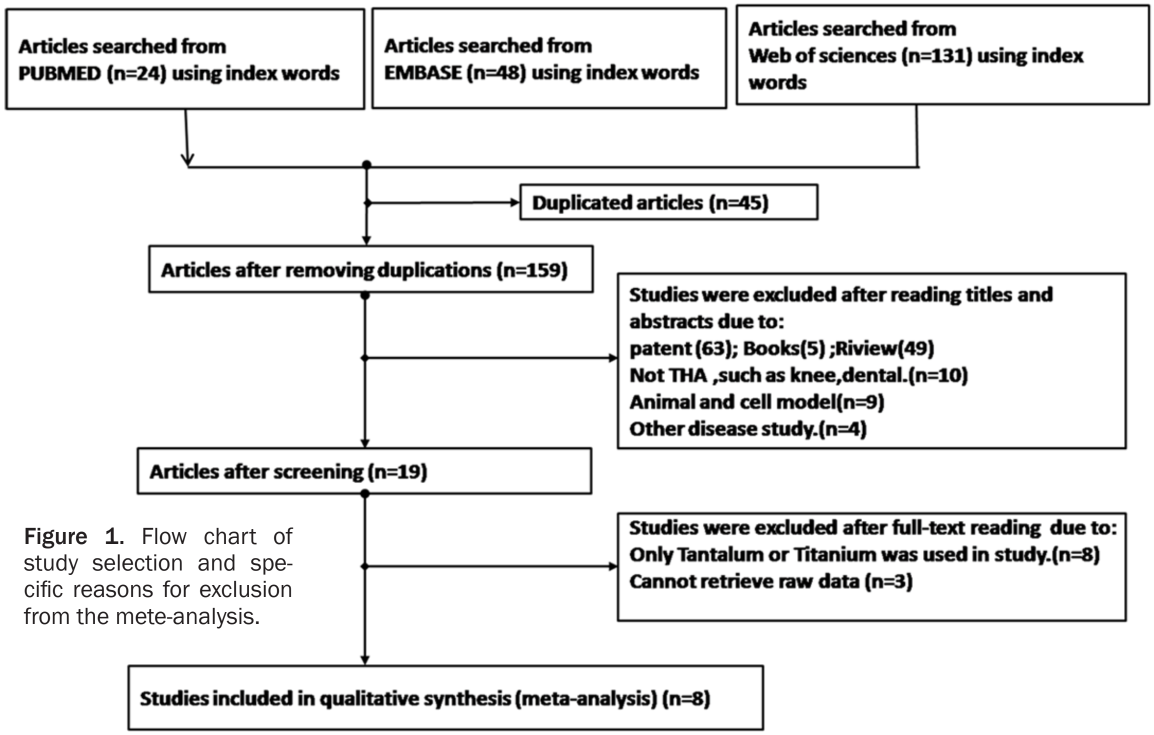

Figure 1. Flow chart of study selection and specific reasons for exclusion from the mete-analysis.

Evaluation of the difference in the HHS between tantalum and titanium acetabular components after THA

There were 6 eligible studies incorporated to estimate the difference in HHS between tantalum and titanium acetabular implants after THA, and the results were showed in **Table 2**. The random-effects model was used for the calculation of the SMD and 95% CI for HHS due to the large heterogeneity. The SMD was positive (SMD = 0.066, 95% CI: -0.44-0.571, **Figure 2**) with the value of *p* more than 0.05 (P = 0.799), which suggested that no significant difference in the HHS was observed between tantalum and titanium acetabular components for patients after receiving THA.

Evaluation of the difference in the instability rate between tantalum and titanium acetabular components after THA

For the analysis of instability rate, the value of I^2 was less than 50% ($I^2 < 0.01\%$), and the fixed-effects model was selected to calculate the OR and the corresponding 95% CI. The results were listed in **Table 3**. The OR was less than 1 (OR = 0.454, **Figure 3**) with the 95% CI ranged from 0.318 to 0.647, and the value of *p* was less than 0.05 (P < 0.001), signifying that there was significant difference in the instability rate between tantalum and titanium acetabular components for patients after receiving THA, and the instability rate in titanium acetabular components group was significantly higher than that in tantalum acetabular implants group.

Evaluation of the difference in the failure rate between tantalum and titanium acetabular components after THA

Eligible data from 3 included studies were incorporated to evaluate the difference in the failure rate between tantalum and titanium acetabular components after THA. The results were described in **Table 3**. Considering the extremely small heterogeneity ($I^2 = 3.5\%$), we adopted the fixed-effects model to calculate the OR and the corresponding 95% CI. The OR was 0.448 (95% CI: 0.282-0.713, **Figure 4**), and the value of *P* was less than 0.05 (P = 0.001), which revealed that there was significant difference in the failure rate between tantalum and titanium acetabular components, and the failure rate in titanium acetabular components group was significantly higher than that in tantalum acetabular implants group after THA.

Table 1. Summary of eligible articles

Study	Methods of defining clinical outcomes	Acetabular components for control group	Acetabular components for case group	Head components	Age (control/case)	Gender (male)	No (control/case
A. T. Tokarski (2015)	According to the methods of CDC	Ti acetabular components: Zimmer; Warsaw, Indiana	Ta acetabular components: Zimmer; Warsaw, Indiana	-	63.2 (26-92)/ 64.7 (25-91)	43.58%	536/454
Anders Troelsen (2015)	Radiographs	Ti acetabular components: Trilogy, Zimmer, Warsaw, IN, USA	Ta acetabular components: Trabecular Metal, Zimmer	Standard offset and a 28 mm head component	-	70.37%	23/23
David C. Ayers (2015)	Radiostereometric	Titanium acetabular cups: Trilogy Acetabular Hip System; Zimmer, Warsaw, Indiana	Tantalum acetabular cups: Trabecular Metal Modular Acetabular System; Zimmer	-	58 ± 7	41.30%	23/23
Jacob T. Munro (2013)	Radiologic outcomes	A titanium fiber metal cup: Trilogy1 Acetabular Hip System; Zimmer	Porous tantalum cup: Trabecular MetalTM Modular Acetabular System; Zimmer	Primary large-head, MoM THA	54.6 (43-79)	63.33%	17/15
Thomas A. Gruen (2005)	Radiolucencies	Porous-coated titanium cups	Porous tantalum (Trabecular Metal, Zimmer, Inc)	A	-	-	40/43
Julien Wegrzyn (2015)	Radiograph	Porous-coated titanium-alloy: Elliptical	Porous tantalum: Hedrocel	A	59 ± 12	60.47%	41/45
S. Mehdi Jafari (2010)	Radiographic	Hemispherical HAcoated titanium acetabular cup: Stryker Orthopaedics, Mahwah, NJ	Elliptical tantalum cetabular cup: TM; Zimmer, Warsaw, IN	-	72 (34-91)/ 66 (26-88)	55.00%	207/79
Thomas A. Gruen (2011)	Radiolucencies	Porous-coated titanium cups	Porous tantalum: Trabecular Metal, Zimmer, Inc	A	-	-	-

CDC: Center for Disease Control. A: A 28-mm femoral head comprised of either cobalt-chromium-molybdenum (Co-Cr-Mo) or zirconia ceramic. -: not mentioned.

Table 2. Meta-analysis of the difference in the HHS between tantalum and titanium acetabular components in THA

Study	SMD	Lower Limit	Upper Limit	P (SMD)	I^2	P (Heterogeneity)	P (Begg's Test)	P (Egger's test)
HHS	0.066	-0.44	0.571	0.799	84.90%	< 0.001	0.707	0.667

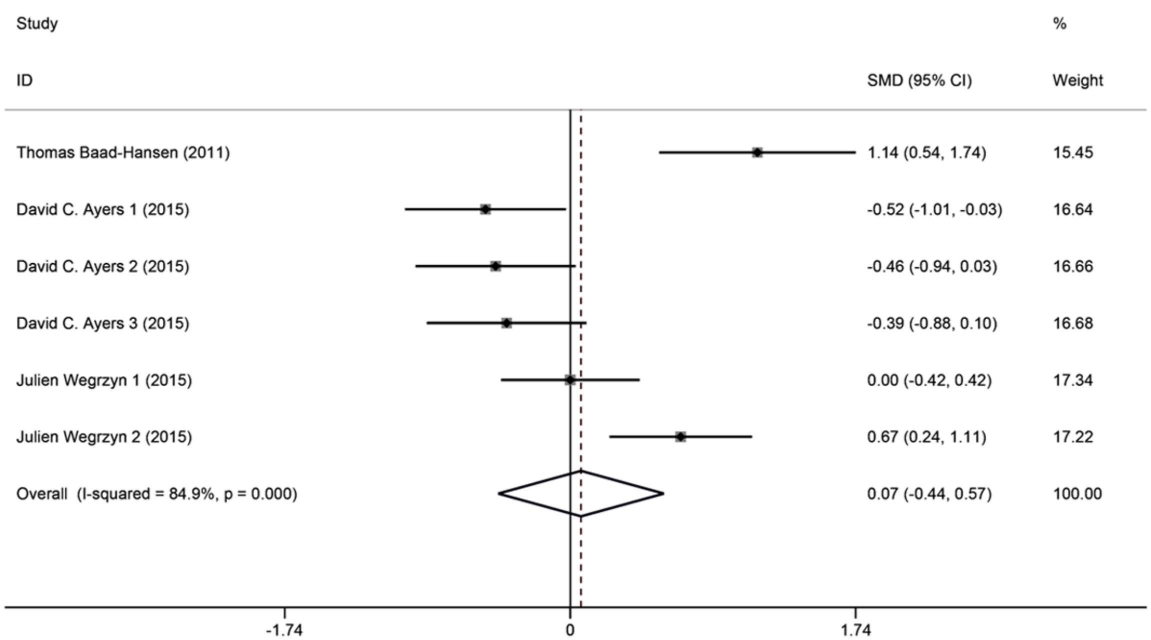

Figure 2. Forest plot of study evaluating the difference in the HHS between tantalum and titanium acetabular components after THA.

Table 3. Meta-analysis of the difference in the instability rate, failure rate and the incidence of gaps between tantalum and titanium acetabular components in THA

Study	OR	Lower Limit	Upper Limit	P (OR)	I^2	P (Heterogeneity)	P (Begg's Test)	P (Egger's test)
Instability rate	0.454	0.318	0.647	< 0.001	< 0.01%	0.399	0.296	0.147
Failure rate	0.448	0.282	0.713	0.001	3.50%	0.335	1.000	0.817
The incidence of gaps	0.403	0.074	2.207	0.295	82.10%	0.004	0.296	0.159

Evaluation of the difference in the incidence of gaps between tantalum and titanium acetabular components after THA

As for the difference in the incidence of gaps between tantalum and titanium acetabular components after THA, 3 relevant studies were included in our meta-analysis. The results were recorded in **Table 3**. The OR and 95% CI were calculated in the random-effects model, since there was large heterogeneity among the included studies. Although the OR was less than 1 (OR = 0.403, 95% CI: 0.074-2.207, **Figure 5**), the value of *p* was more than 0.05 (P = 0.295). And we still believed that there was no significant difference in the incidence of gaps between tantalum and titanium acetabular components after THA.

Publication bias

The Begg's funnel plots were constructed for the visual examination of overt publication bias for the incorporated case-control studies. The funnel plot shapes presented no obvious evidence of asymmetry for all the analyses (**Figure 6A-D**). Then, an Egger's test was used for further investigation, and the results were displayed in **Tables 2** and **3**. All the values of *P* were higher than 0.05, indicating that no signifi-

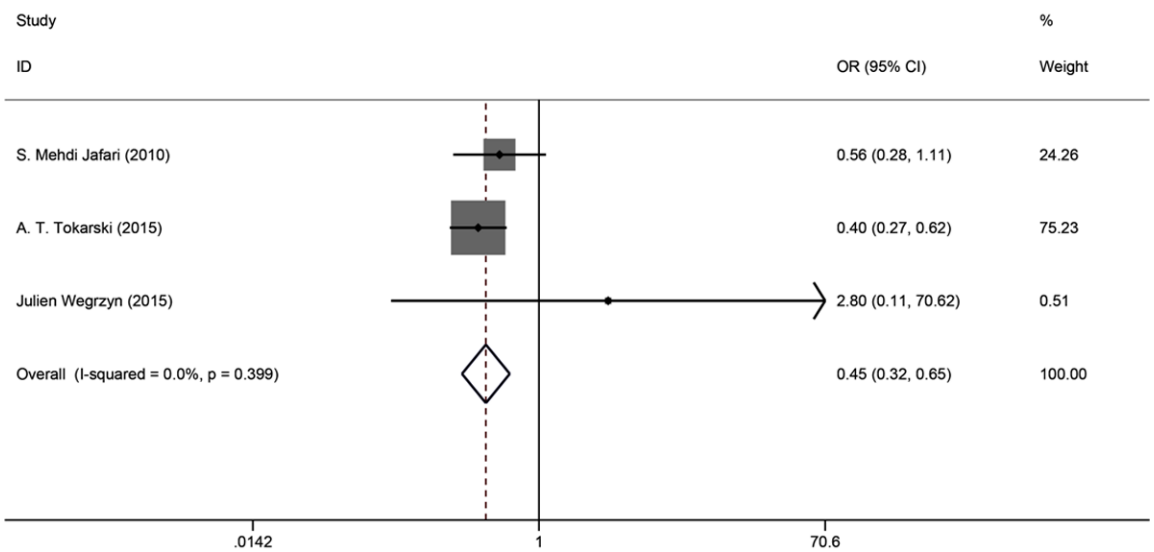

Figure 3. Forest plots of study assessing the difference in the instability rate between tantalum and titanium acetabular components after THA.

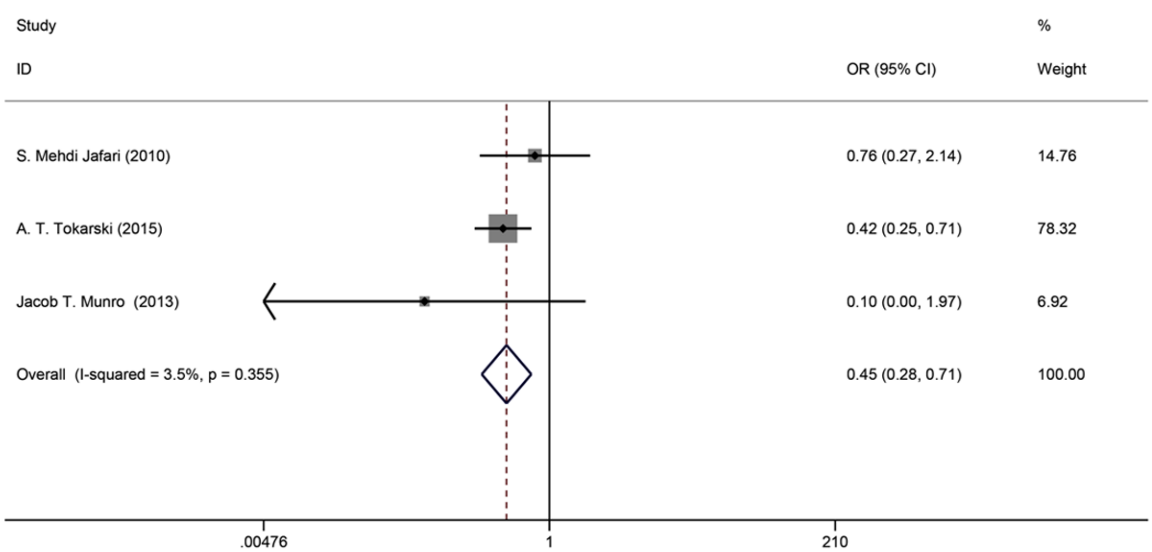

Figure 4. Forest plots of study evaluating the difference in the failure rate between tantalum and titanium acetabular components after THA.

cant publication bias was found in all the analyses.

Discussion

In this meta-analysis, our purpose was to evaluate the difference in the HHS, instability rate, failure rate and the incidence of gaps between tantalum and titanium acetabular components after THA. Relevant data from 8 eligible studies were incorporated for the analysis. And the results showed that compared with the tantalum acetabular components, the titanium acetabular components had significantly higher instability rate and failure rate after THA, while in terms of the HHS and the incidence of gaps, patients receiving the two acetabular components in THA had similar HHS and the incidence of gaps after treatment.

THA has provided favorable clinical outcomes for over four decades, and has been recommended to younger, more active patients with end-stage arthritis of the hip [2, 3]. It has been

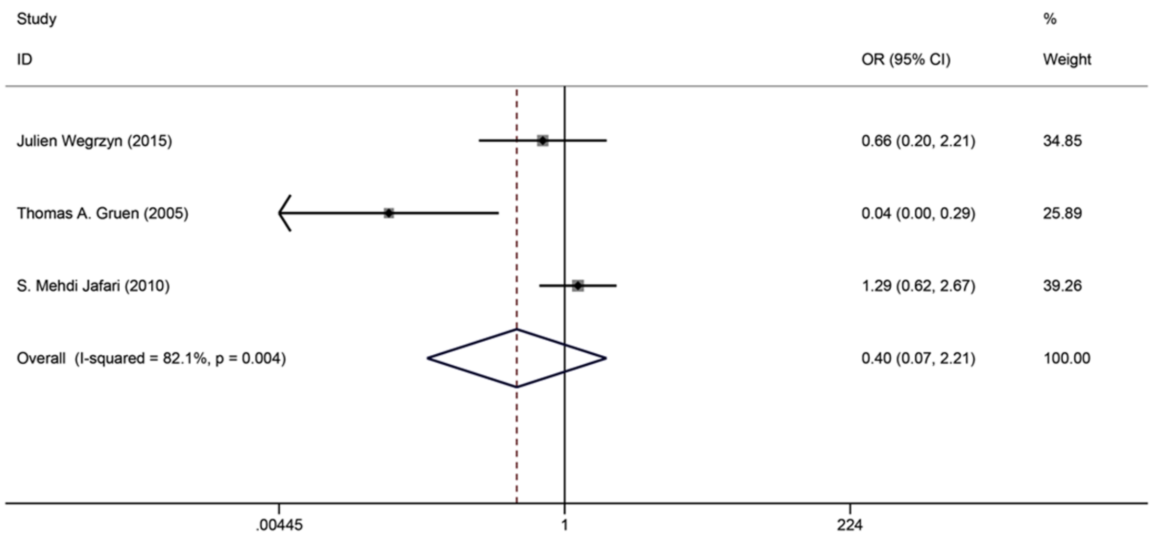

Figure 5. Forest plot of study estimating the difference in the incidence of gaps between tantalum and titanium acetabular components after THA.

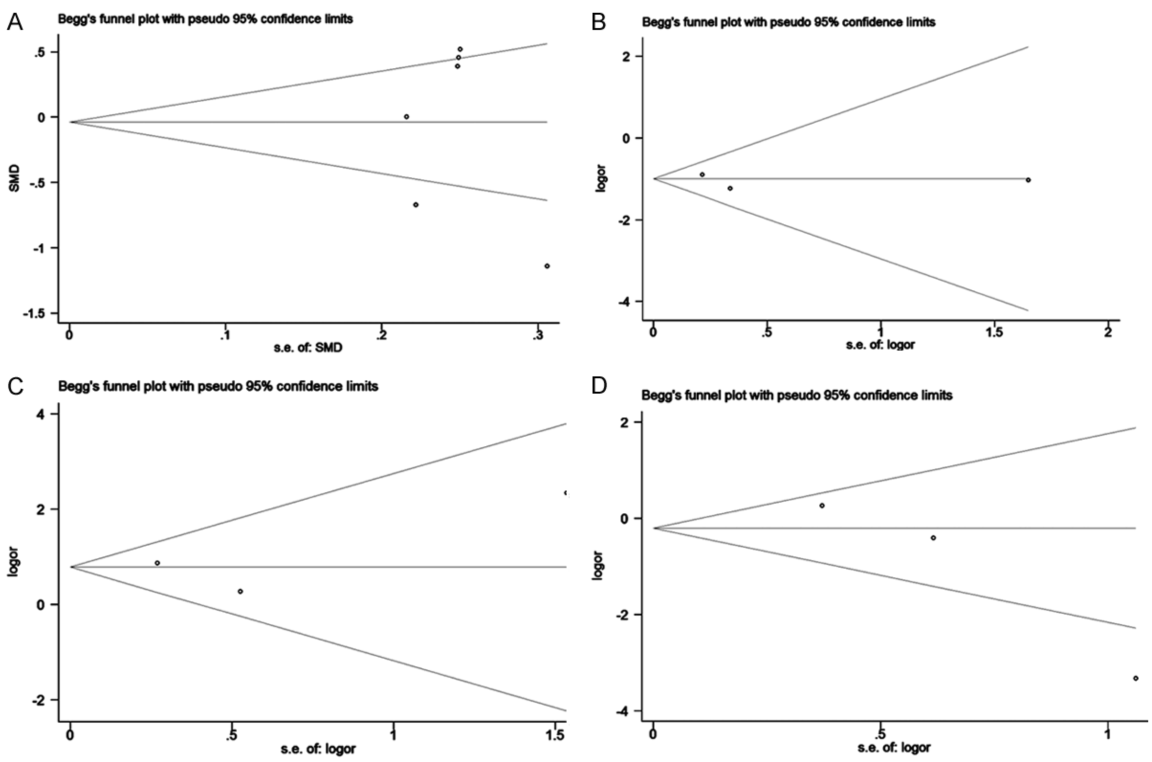

Figure 6. Funnel plots of studies assessing the difference in the HHS (A), the instability rate (B), the failure rate (C) and the incidence of gaps (D) between tantalum and titanium acetabular components after THA.

estimated by projection models that there would be an increase in demand for revision procedures over the next several decades [20]. Instability, following primary THA, is a challenging problem and a common indication for revision THA [21]. The revision THA is the treatment of choice to address the instability resulting from component dislocation [21]. The main common causes of revision THA include instability or dislocation, mechanical loosening, and infection, among which instability or dislocation is the predominant reason accounting for approximately 22.5% revision [22]. The incidence of dislocations is 59% within the first 3 months after surgeries and 77% within the first year [23].

Titanium, together with its alloys, is one of the most widely used materials for bone fixation in THA [24, 25]. The titanium-based components in THA have been reported to have high levels of patient satisfaction in the long-term follow-up after treatment [11]. However, various types of metallic degradation products were detected in the periprosthetic tissues of individuals receiving titanium-based hip components, which may be responsible for the failure of THA [24]. Munro et al, reported that the failure rate of patients receiving titanium acetabular components in THA was similar with that of individuals treated with tantalum acetabular components [17]. In our meta-analysis by incorporating all relevant data together, we detected that patients receiving titanium acetabular implants had significantly higher failure rate and instability rate than those receiving tantalum acetabular components.

The uncemented tantalum acetabular components, introduced in 1997, possess high degree of porosity, rough-surface micro-texture and low modulus of elasticity [26]. When compared with titanium acetabular components, the tantalum acetabular components have higher-value porosity, lower bulk stiffness and larger friction coefficient, which may lead to an increase in component fixation for THA [18]. A prospective study, with 613 primary THAs rolled in, observed that patients receiving tantalum acetabular components had excellent initial stability and apparent ingrowth during 2- to 10-year follow-up after treated with THA [26]. In our study, we conducted a meta-analysis, which was a powerful and rigorous statistical method, and observed that although patients in titanium and tantalum acetabular components groups had similar HHS and the incidence of gaps after THA, the instability rate and failure rate in tantalum acetabular components group were significantly lower than those in titanium acetabular implants group. And we inferred that patients receiving tantalum acetabular components had more favorable clinical outcomes after primary or revision THA, when compared with individuals receiving titanium acetabular implants. According to the previous study [9], we deduced that the reason why tantalum acetabular components had more favorable clinical outcomes might be associated with the characteristics of tantalum acetabular implants such as the higher potential of osseointegration and the special three-dimensional structure of the surface.

The HHS, which is firstly published in 1969, is a clinician-based outcome measure for a variety of hip disabilities and approaches of treatment [27]. The HHS, whose validity and reliability have been confirmed, is commonly used to assess the clinical outcome of THA [28-30]. There are 10 items in HHS with the domains related to the ability of motion, pain, absence of deformity and pain [27]. The data from a randomized controlled trial that was published in 2011 demonstrated that the HHS in tantalum acetabular components was significantly higher than that in titanium acetabular components after THA [14]. However, relevant clinical studies published in 2015 exhibited different results [16, 18]. In our study, we selected the HHS as one parameter of the clinical outcomes for patients receiving the titanium or tantalum acetabular implants in THA, and with a large sample size, our results signified that the HHS in patients with the two implants was similar.

This meta-analysis has some limitations that should be taken into consideration. Firstly, the heterogeneity in the analyses of HHS and the incidence of gaps was significant, which might be resulted from the incorporated studies of these two analyses that included patients receiving both the primary and revision THA. With more relevant studies available, the subgroup analysis based on the primary or revision THA should be performed. Secondly, the follow-up periods of the included studies were not exactly the same, which might cause bias in our results. Additionally, the unpublished literatures were not considered in our meta-analysis due to the unavailable raw data.

The current meta-analysis suggests that considering the instability and failure in primary or revision THA, patients receiving tantalum acetabular components are more likely to have favorable clinical outcomes after THA, when compared with those receiving titanium acetabular components. And the tantalum acetabular components should be recommended to patients treated with THA.

Disclosure of conflict of interest

None.

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References

[1] Sculco PK, Cottino U, Abdel MP, Sierra RJ. Avoiding Hip Instability and Limb Length Discrepancy After Total Hip Arthroplasty. Orthop Clin North Am 2016; 47: 327-34.

[2] Sheth NP, Melnic CM, Rozell JC, Paprosky WG. Management of Severe Femoral Bone Loss in Revision Total Hip Arthroplasty. Orthop Clin North Am 2015; 46: 329-42.

[3] Shen C, Tang ZH, Hu JZ, Zou GY, Xiao RC, Yan DX. Does cross-linked polyethylene decrease the revision rate of total hip arthroplasty compared with conventional polyethylene? A meta-analysis. Orthop Traumatol Surg Res 2014; 100: 745-50.

[4] Patel A, Pavlou G, Mújica-Mota R, Toms A. The epidemiology of revision total knee and hip arthroplasty in England and Wales a comparative analysis with projections for the United States. A study using the National Joint Registry dataset. Bone Joint J 2015; 97: 1076-81.

[5] Jafari SM, Bender B, Coyle C, Parvizi J, Sharkey PF, Hozack WJ. Do tantalum and titanium cups show similar results in revision hip arthroplasty? Clin Orthop Relat Res 2010; 468: 459-65.

[6] Pulido L, Rachala SR, Cabanela ME. Cementless acetabular revision: past, present, and future. Int Orthop 2011; 35: 289-98.

[7] Della Valle CJ, Shuaipaj T, Berger RA, Rosenberg AG, Shott S, Jacobs JJ, Galante JO. Revision of the acetabular component without cement after total hip arthroplasty. J Bone Joint Surg 2005; 87: 1795-800.

[8] Park DK, Della Valle CJ, Quigley L, Moric M, Rosenberg AG, Galante JO. Revision of the acetabular component without cement. J Bone Joint Surg 2009; 91: 350-5.

[9] Tokarski A, Novack T, Parvizi J. Is tantalum protective against infection in revision total hip arthroplasty? Bone Joint J 2015; 97: 45-9.

[10] Lachiewicz PF, Soileau ES. Tantalum components in difficult acetabular revisions. Clin Orthop Relat Res 2010; 468: 454-8.

[11] Sandiford N, Butler-Manuel A, Apthorp H, East D, Hinves B, Shepperd J. Primary total hip arthroplasty with a proximally HA-coated titanium femoral component: results at 10-15-year follow-up. Eur J Orthop Surg Traumatol 2014; 24: 1211-5.

[12] Ollivier M, Parratte S, Galland A, Lunebourg A, Argenson JN. Are titanium-on-titanium TiAl6V4 modular necks safe in total hip arthroplasty for non-overweight patients? Results of a prospective series at a minimum follow-up of 7 years. Eur J Orthop Surg Traumatol 2015; 25: 1147-52.

[13] Batuyong ED, Brock HS, Thiruvengadam N, Maloney WJ, Goodman SB, Huddleston JI. Outcome of porous tantalum acetabular components for Paprosky type 3 and 4 acetabular defects. J Arthroplasty 2014; 29: 1318-22.

[14] Baad-Hansen T, Kold S, Nielsen PT, Laursen MB, Christensen PH, Soballe K. Comparison of trabecular metal cups and titanium fiber-mesh cups in primary hip arthroplasty: a randomized RSA and bone mineral densitometry study of 50 hips. Acta Orthop 2011; 82: 155-60.

[15] Gruen TA, Poggie RA, Lewallen DG, Hanssen AD, Lewis RJ, O'Keefe TJ, Stulberg SD, Sutherland CJ. Radiographic evaluation of a monoblock acetabular component: a multicenter study with 2-to 5-year results. J Arthroplasty 2005; 20: 369-78.

[16] Wegrzyn J, Kaufman KR, Hanssen AD, Lewallen DG. Performance of Porous Tantalum vs. Titanium Cup in Total Hip Arthroplasty: Randomized Trial with Minimum 10-Year Follow-Up. J Arthroplasty 2015; 30: 1008-13.

[17] Munro JT, Masri BA, Duncan CP, Garbuz DS. High complication rate after revision of large-head metal-on-metal total hip arthroplasty. Clin Orthop Relat Res 2014; 472: 523-8.

[18] Ayers DC, Greene M, Snyder B, Aubin M, Drew J, Bragdon C. Radiostereometric Analysis Study of Tantalum Compared with Titanium Acetabular Cups and Highly Cross-Linked Compared with Conventional Liners in Young Patients Undergoing Total Hip Replacement. J Bone Joint Surg 2015; 97: 627-34.

[19] Troelsen A, Greene ME, Ayers DC, Bragdon CR, Malchau H. A Novel Method for Assessment of Polyethylene Liner Wear in Radiopaque Tantalum Acetabular Cups: Clinical Validation in Patients Enrolled in a Randomized Controlled Trial. J Arthroplasty 2015; 30: 2354-9.

[20] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg 2007; 89: 780-5.

[21] Sheth N, Melnic C, Paprosky W. Evaluation and management of chronic total hip instability. Bone Joint J 2016; 98: 44-9.

[22] Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ. The epidemiology of revision total hip arthroplasty in the United States. J Bone Joint Surg 2009; 91: 128-33.

[23] Woo RY, Morrey BF. Dislocations after total hip arthroplasty. J Bone Joint Surg 1982; 64: 1295-306.
[24] Grosse S, Haugland HK, Lilleng P, Ellison P, Hallan G, Høl PJ. Wear particles and ions from cemented and uncemented titanium-based hip prostheses-A histological and chemical analysis of retrieval material. J Biomed Mater Res B Appl Biomater 2015; 103: 709-17.
[25] Jauregui JJ, Banerjee S, Cherian JJ, Elmallah RK, Pierce TP, Mont MA. Early Outcomes of Titanium-Based Highly-Porous Acetabular Components in Revision Total Hip Arthroplasty. J Arthroplasty 2015; 30: 1187-90.
[26] Noiseux NO, Long WJ, Mabry TM, Hanssen AD, Lewallen DG. Uncemented porous tantalum acetabular components: early follow-up and failures in 613 primary total hip arthroplasties. J Arthroplasty 2014; 29: 617-20.
[27] Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris hip score (HHS), hip disability and osteoarthritis outcome score (HOOS), Oxford hip score (OHS), Lequesne index of severity for osteoarthritis of the hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) hip and knee questionnaire. Arthritis Care Res (Hoboken) 2011; 63: S200-S7.
[28] Soderman P, Malchau H. Is the Harris hip score system useful to study the outcome of total hip replacement? Clin Orthop Relat Res 2001; 189-97.
[29] Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. J Bone Joint Surg 1969; 51: 737-55.
[30] Hoeksma H, Van den Ende C, Ronday H, Heering A, Breedveld F, Dekker J. Comparison of the responsiveness of the Harris Hip Score with generic measures for hip function in osteoarthritis of the hip. Ann Rheum Dis 2003; 62: 935-8.