ORIGINAL ARTICLE
Hip Pelvis 26(2): 92-98, 2014
http://dx.doi.org/10.5371/hp.2014.26.2.92

Print ISSN 2287-3260
Online ISSN 2287-3279
Hip & Pelvis

Meta-analysis of the Incidence and Risk Factors for Squeaking after Primary Ceramic-on-ceramic Total Hip Arthroplasty in Asian Patients

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Purpose: The purpose of this study was to assess the squeaking incidence and risk factors after primary ceramic-on-ceramic total hip arthroplasty (THA) in Asian patients using meta-analysis.

Materials and Methods: We performed a meta-analysis of published data on the squeaking incidence and risk factors from 2000 to 2013. Eight studies in Asians were analyzed for both squeaking incidence and risk factors and 25 studies in Western patients were analyzed for squeaking incidence. The data collected were: patient factors, surgical factors and implantation factors.

Results: The overall incidence of hip squeaking was 2.7% in Asians and 3.1% in Westerners. This difference was not statistically significant. The only significant risk factor was an increase in the acetabular cup abduction angle. Of the factors, the cup abduction angle was the only significant risk factor for the occurrence rate of squeaking, and the occurrence rate tended to increase with increasing angle.

Conclusion: The incidence of squeaking in Asians after primary ceramic-on-ceramic THA is 2.7% and is similar to that in Westerners. The increased cup abduction angle is associated with squeaking; therefore, surgeons should be careful not to implant the cup at a too steep abduction angle.

Key Words: Total hip arthroplasty, Ceramic-on-ceramic bearing, Squeaking, Noise, Meta-analysis

INTRODUCTION

Total hip arthroplasty (THA) using ceramic-on-ceramic bearings is characterized by a low wearing rate, no release of metal ions, resistance to scratches, and hydrophilic properties, and thus has a better clinical prognosis than metal-on-polyethylene bearing surfaces[1]. Recently, however, a serious clinical problem has emerged-the occurrence of squeaking following THA using ceramic-on-ceramic bearings-which negatively influences patients' satisfaction[2]. When patients do not complain about pain and mechanical symptoms, most squeaking cases are just followed up without any additional treatments, but there is a report that squeaking accompanying pain might be related to ceramic joints[3].

Several causes of squeaking can be classified into three categories: implantation factors, patient factors, and surgical factors. The implantation factors include

Submitted: April 15, 2014 1st revision: May 8, 2014
Final acceptance: May 30, 2014
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the shape of prosthesis and impingement by an elevated-rim liner[4], whereas the patient factors are young age, heavy weight, and tall patients. Lastly, the surgical factors are malposition of the acetabular cup and reduction of soft tissue tension[5].

A few reports have suggested that the occurrence rates of impingements and ceramic fractures are higher in Asian populations than in Westerners, possibly due to different somatotypes as well as life styles. To the best of our knowledge, however, no studies have addressed the occurrence rate of squeaking and its risk factors in an Asian population.

The main objective of this meta-analysis was to determine the occurrence rate of squeaking following THA in Asians and to compare it with that in Westerners. In addition, we intended to find the risk factors for squeaking in Asians.

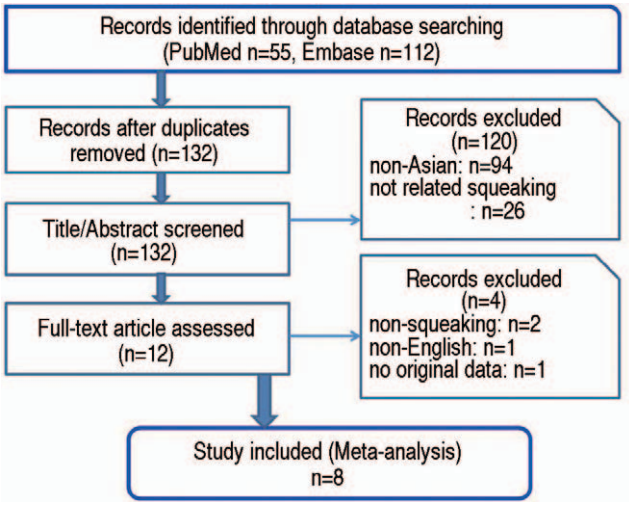

Fig. 1. Literature search in databse.

MATERIALS AND METHODS

Literature (publication years, 2000-2013) reporting the results of primary THA using ceramic-on-ceramic bearings was searched using PubMed and the Embase database with the following key words: 1) hip AND squeak, 2) squeaking AND hip, 3) ceramic AND hip AND squeak, and 4) ceramic AND hip AND noise. Overlapping publications and those written in languages other than English were excluded; a total of 132 publications was finally included in our study. Of these, only 8 studies dealing with Asian populations were included in the meta-analysis[6-13]: 4 Korean, 1 Chinese, 1 Japanese, and 2 Taiwanese studies (Fig. 1). Studies that involved Westerners (n=25) were analyzed for the occurrence rate of squeaking[2,4,14-36]. Although our literature searches were not limited to squeaking, but also included all types of sounds coming from a hip joint such as clicking, popping, clunking, and grinding, only studies dealing with squeaking (defined as a high-pitched audible sound) were included and analyzed (Table 1).

The total number of patients, the number of patients experiencing noise, the number of patients experiencing squeaking, and the length of the follow-up period were collected and analyzed for the impact of implantation factors, patient factors, and surgical factors. Patient factors included age, sex, body mass index (BMI), and diagnosis; surgical factors were surgical approaches, and position of the acetabular cup (abduction and anteversion). Implantation factors were the types of the acetabular cup, the size of the femoral head, and the types of femoral stem. The impacts of sex, diagnosis, and surgical approaches on the occurrence rate of squeaking were stratified and analyzed using the ratio of male to female patients, avascular necrosis of the femoral head, and lateral approach, respectively. The

Table 1. Studies Included in the Meta-analysis in Asian

Author	Year	Hips (n)	Squeaking (n)	Noise (n)	Level of evidence	Study type
Baek et al.	2008	71	1	14	4	Case series
Kim et al.	2010	173	8	19	4	Case series
Kim et al.	2010	102	1	2	4	Case series
Cai et al.	2012	51	2	2	3	Case control
Chen et al.	2012	413	0	0	4	Case series
Kuo et al.	2012	143	0	4	4	Case series
Yoon et al.	2012	75	2	12	4	Case series
Tsukada et al.	2013	124	0	6	4	Case series

types of acetabular cup were classified into either a metallic-rim acetabular cup or others. Lastly, the types of femoral stem were classified into a titanium-aluminum-vanadium alloy stem and a titanium-molybdenum-zirconium-iron alloy stem.

We analyzed the squeaking occurrence rate only for Westerners because of considerable variability in conventional squeaking incidence analysis, which makes it difficult to compare the occurrence rates directly; the total number of patients and that of patients experiencing squeaking were collected to analyze the occurrence rate.

Comprehensive Meta-Analysis software (CMA, version 2.0; Statistical Solutions, Cork, Ireland) was used for statistical analysis. For analysis of the occurrence rate, heterogeneity between studies included in the meta-analysis was analyzed. The fixed effects model was applied if heterogeneity was <50%; otherwise, the random effects model was applied considering the variations among studies. A meta-regression analysis was used to assess the correlation between the squeaking occurrence rate and respective factors.

RESULTS

Our meta-analysis included a total of 1,152 cases of primary THA using ceramic-on-ceramic bearings in Asian subjects. The average age was 43.9 years; 495 subjects were male and 657 subjects were female; the average BMI was 23.8 kg/m^2 (range, 22.0-26.0 kg/m^2). The average follow-up period was 87 months (range, 29-139 months). The most common diagnosis was avascular necrosis of the femoral head (563 cases) followed by degenerative arthritis, hip joint dysplasia, and rheumatoid arthritis. Of 59 subjects (5.1%) who experienced noise, squeaking was reported in 14 cases (1.2%). For the analysis of the noise occurrence rate, the random effects model was applied because of high heterogeneity between studies (90.5%); in contrast, the fixed effects model was used for the analysis of the squeaking occurrence rate given its low heterogeneity between studies (46.4%). We found that the occurrence rates for noise and squeaking were 4.5% and 2.7%, respectively (Fig. 2).

Correlation analysis, which included 8 studies[6-13], revealed that patient factors, i.e., age (P=0.55), BMI (I=0.07) , and sex (P=0.29), did not influence the occurrence rate of squeaking. Most surgical factors, i.e. surgical approaches (P=0.11), diagnosis (P=0.10), cup anteversion (P=0.26), as well as implantation factors, i.e., the size of the femoral head (P=0.72), types of the acetabular cup (P=0.58), and types of femoral stems (P=0.13) had no significant impact on the occurrence rate of squeaking. Of the surgical factors, only the cup abduction angle was a significant factor for the occurrence rate of squeaking (P=0.0063). The average abduction angle of the acetabular cup was 45.3˚, and the occurrence rate tended to increase with increasing angle (Table 2).

Our analysis of the occurrence rate of squeaking in Westerners included 13,643 cases of primary THA using

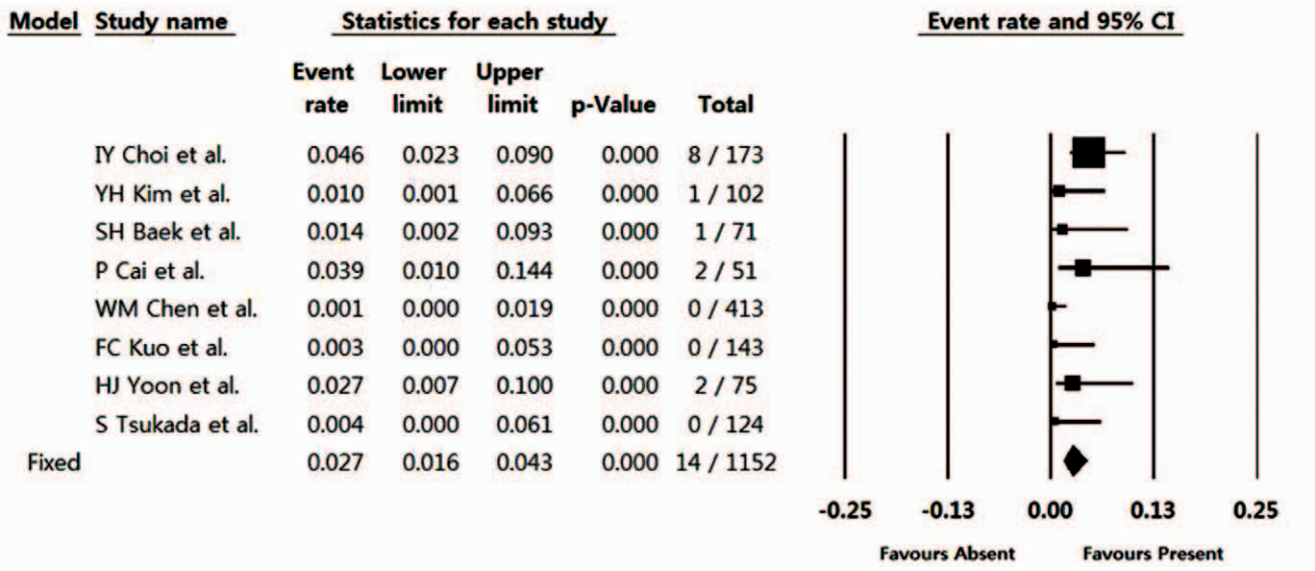

Fig. 2. Summary of result of squeaking incidence in Asian.

ceramic-on-ceramic bearings. The average age of the patients was 53.5 years; squeaking was reported in 401 cases. Because of high heterogeneity between studies (92.63%), the random effects model was applied and showed the occurrence rate of 3.1% (Fig. 3). In addition, we included 33 studies on both Asian and Western populations; their overall heterogeneity was 90.68%. The mixed-effect analysis revealed the squeaking occurrence rate of 2.7%. There was no statistically significant difference between Asians and Westerners in the incidence rate (P=0.20).

Table 2. Summary of Result of Incidence Factor Meta-analysis

Parameter	Hip (n)	Study (n)	Analysis type	Difference (95% CI)	P-value
Age	1,152	8	Meta-regression	−0.03-0.06	0.55
Sex	1,152	8	Meta-regression	−0.06-0.02	0.29
Body mass index	1,152	8	Meta-regression	−1.08-0.06	0.07
Follow up time	1,152	8	Meta-regression	−0.02-0.01	0.32
Approach	1,152	8	Meta-regression	−0.02-0.01	0.11
Diagnosis	1,152	8	Meta-regression	−0.04-0.003	0.10
Abduction angle	1,077	7	Meta-regression	0.07-0.42	0.0063
Anteversion	710	4	Meta-regression	−0.14-0.52	0.26
Head size	688	6	Meta-regression	−0.05-0.03	0.72
Stem	1,152	8	Fixed effect model	0.02-0.06	0.13
Cup	1,152	8	Fixed effect model	0.02-0.05	0.58

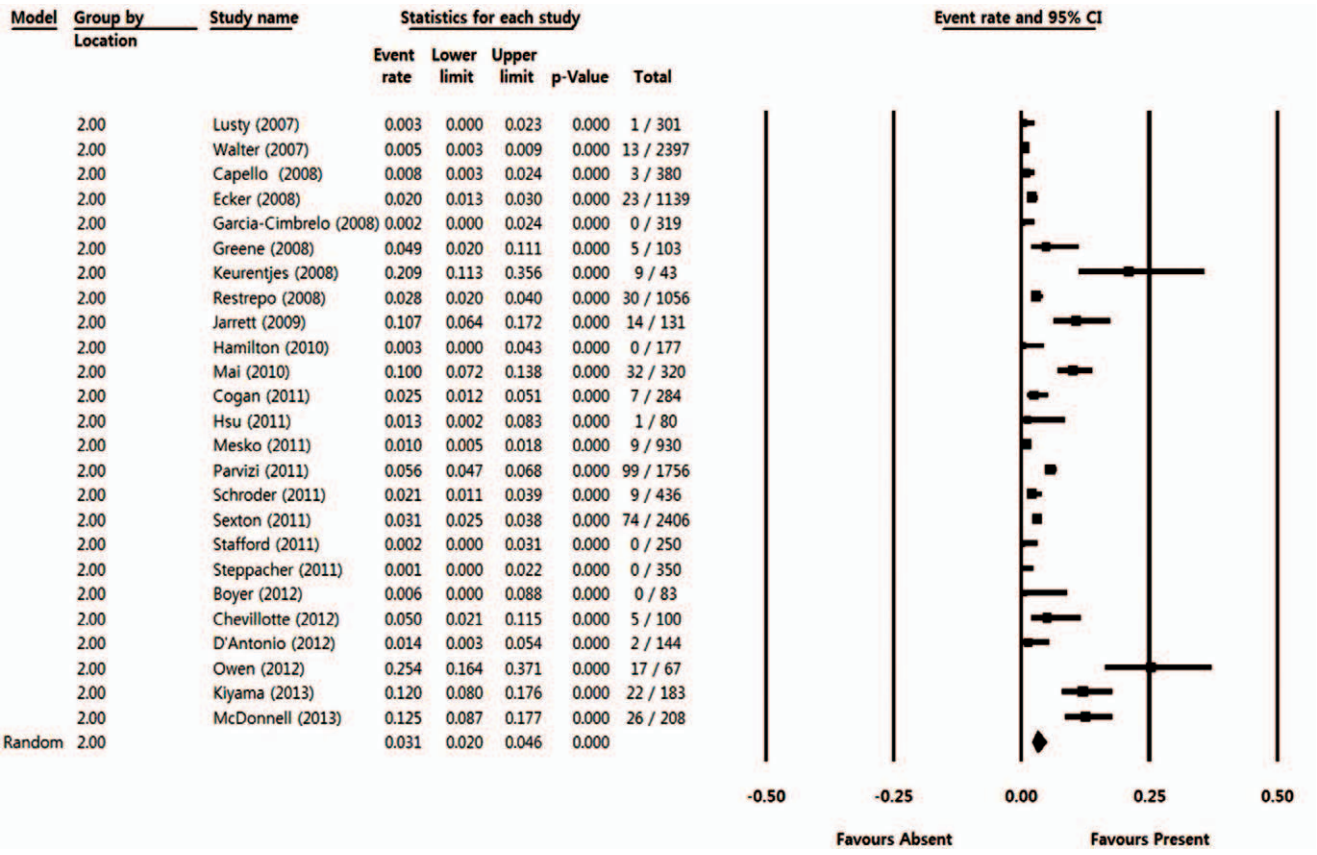

Fig. 3. Summary of result of squeaking incidence in Western.

DISCUSSION

THA using ceramic-on-ceramic bearings is characterized by low wearing rate, no release of metal ions, resistance to scratches, and great biocompatibility. Furthermore, compared to other articular surfaces, ceramic-on-ceramic bearings are more durable and thus are widely used for young and active patients[15]. But they should be chosen carefully, as they frequently cause noise and abnormal sounds like squeaking, which makes patients' daily life difficult and often requires re-operations.

The proposed mechanisms responsible for squeaking include mismatching between articular surfaces[37], "stick and slip" occurring due to microseparation of the articular surfaces[38], destruction of fluid film lubrication due to "edge loading"[39], femoral neck-acetabular component rim impingement[40], impingement owing to abnormal position of the acetabular cup[2], short femoral neck[17], and "dry joint" environment[41].

Of the proposed mechanisms, "edge loading" is one of the most important, and we expected that the Asian population would have a higher occurrence rate of squeaking because of a wider range of motion and likely to have more impingement when the hip joint is deep bending. Multiple studies have reported that squeaking occurs when the hip joint is bending or the subject is sitting down or standing up[5,18,20]. Similarly, one of the studies included in our meta-analysis reported that bending the hip joint more than 70˚ or extensive internal rotation may cause squeaking[8]. Unexpectedly, the occurrence rate of squeaking in Asians was found to be 2.7%, which is not significantly different from values reported by previous studies, which ranged from 0.7% to 22.9%. Our result is similar to a previous meta-analysis, which reported the occurrence rate of squeaking of 2.4%[42]. Taken together, these data indicate that a wider range of motion in Asians does not necessarily increase the risk of impingements between implants that cause squeaking.

In the present study, we found that none of the patient factors was significantly correlated with the occurrence rate of squeaking, whereas other studies have demonstrated that age, height and body weight are very likely risk factors for squeaking. In particular, young, tall, and heavy patients are known to have a higher risk of squeaking[5]. One study concluded that male patients are more likely to have squeaking[7], whereas another study reported that young patients with a wide range of motion have a higher noise incidence[11].

Our correlation analysis between surgical factors and squeaking revealed that the wide abduction angle elevates the risk of squeaking. Walter et al.[5] defined the ideal angles of the acetabular cup for abduction and anteversion as 45˚ ±10˚ and 25˚ ±10˚, respectively. None of the studies included in our meta-analysis reported the abduction angle of the acetabular cup or surgical approaches as risk factors. Lastly, implantation factors also did not influence the occurrence rate of squeaking. When a Trident acetabular cup (Stryker, Mahwah, NJ, USA) was used, the occurrence rate of squeaking was elevated; this might be caused by a difference between an elevated metal rim (a specific feature of the product) and the lock mechanism. On the other hand, when Accolade and Omnifit femoral stems (both from Stryker) were compared using the same Trident acetabular cup, the use of Accolade resulted in a higher incidence rate of squeaking. Such differences might be due to titanium alloys with lower modulus of elasticity[43].

There are several limitations to the present study. Firstly, it is difficult to extrapolate the results in general due to a small number of studies included in our meta-analysis. However, the occurrence rate of squeaking is inherently low, which makes it necessary to use a wide range of studies in the analysis to identify the risk factors; furthermore, it is worth noting that we performed the meta-analysis exclusively for the Asian population. Secondly, we were able to retrieve results only from the published literature, which may lead to publication bias, including issues with data deviations as well as accuracy, which may lead to biased conclusions.

CONCLUSION

In the Asian population, the squeaking occurrence rate following primary ceramic-on-ceramic THA was found to be 2.7%; this was similar to the occurrence rate for Westerners (3.1%). The analysis of risk factors revealed that the larger abduction angle of the acetabular cup was associated with the higher occurrence rate of squeaking.

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