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ORIGINAL ARTICLE • HIP - ARTHROPLASTY

Is patient satisfaction related to patient reported sounds from ceramic on ceramic total hip arthroplasty? A study of 265 hips

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Abstract

Introduction The ideal method and implant to perform total hip arthroplasty (THA) is still a debated topic. Ceramic on ceramic (CoC) bearings have favourable wear properties, but squeaking has been reported as an unwanted side effect. We aimed to determine the rate of noise generation from CoC hips and investigate whether there is a relationship with patient satisfaction.

Methods A total of 246 consecutive CoC bearing uncemented THA were retrospectively identified in a single institution. Post-operatively patients were sent a postal questionnaire to evaluate their reported sounds and satisfaction with their THA. Uni- and multi-variate analyses were performed to identify potential predictor variables for reported post-operative sounds.

Results Questionnaires were returned by 172 patients (70% return rate). 24% reported sounds from their hips with 11% reporting a squeak. Median satisfaction levels were minimally, but significantly less for "noisy" (9/10) than "quiet" hips (10/10) (median difference = − 1, 95% CI − 2 to 0, $p < 0.001$). Compared to those with "noisy" hips, patients with "quiet" hips were 1.7 times (95% CI 1.3–2.5, $p = 0.0002$) more likely to report a "forgotten" hip. Younger age ($p < 0.043$) and increased anteversion ($p < 0.021$) were predictors for reported sounds.

Conclusion We have identified a high rate of "noisy" hips in this series of CoC THA with a significant inverse relationship between "noisy" hips and patient satisfaction levels. In our unit, we are moving towards the use of ceramic on cross-linked polyethylene bearings as a result of these findings and the excellent survivorship of this bearing combination.

Keywords Hip · Ceramic · Noise · Squeak · Arthroplasty

Introduction

Despite being perhaps the most successful orthopaedic procedure undertaken, the ideal method and implant to perform total hip arthroplasty (THA) is still a debated topic. The implanted bearing surface is one such subject.

Ceramic on ceramic (CoC) bearings gained in popularity due to their favourable in vitro volumetric wear properties and low rates of osteolysis compared to metal on polyethylene (MoP) and metal on metal (MoM) implants [1–3]. One unfavourable characteristic of CoC bearing is squeaking, with the incidence in large patient cohorts (> 500) ranging from 0.8 to 6.4% [4–11].

Results from the UK National Joint Registry have shown the proportion of CoC bearings implanted have decreased in recent years with squeaking suggested to be a factor in this trend [12]. In 2005, 17.1% of uncemented THA had a CoC bearing, increasing to 44.7% in 2011, before declining in recent years to 28.8% in 2015 [13]. This coincides with an increase in the squeaking phenomenon gaining attention in the orthopaedic and mainstream literature.

With favourable wear characteristics, CoC makes an attractive bearing choice for younger patients, who put higher demands on their THA over a longer period of time. Patient activity levels and function have been reported extensively following CoC THA, but little is published on patient reported satisfaction in patients with a "noisy" hip.

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Aim

Our primary aim was to determine the rate of noise generation from CoC hips and investigate if this influences patient satisfaction.

Our secondary aims were to determine whether a "noisy" hip could be predicted from the patient demographics, implanted head size, version and inclination of the implanted acetabular cup.

Methods

In our retrospective series, we identified 246 consecutive uncemented THAs (Corail stem, Pinnacle cup, Biolox Delta head/liner. DePuy, Warsaw, Indiana, USA). All surgeries were performed in a single institution by six surgeons between September 2007 and August 2010. All were performed through the posterior approach in the lateral decubitus position. Intraoperative cup position for version was confirmed by use of the transverse acetabular ligament (TAL). Patients were excluded if their procedure was performed for acute/chronic trauma, infection, malignancy, previous surgery with metalwork in situ or a revision arthroplasty.

The study was approved by the local research and development department with all patients giving informed consent to their participation.

Demographic, surgical and implant specific data along with post-operative outcome/complications were gathered from medical records, electronic patient records, theatre logs and locally collected National Joint Registry records. Post-operative standardised, calibrated radiographs were reviewed and the acetabular orientation calculated using validated radiological software (Wearwithall, Wrightington, UK) [14].

Patients were sent a simple outcome questionnaire with six questions relating to feelings of instability, dislocation, sounds, sensations, pain or limitations to their daily life from their operated hip (Appendix 1). Questionnaires were sent out on mass to the cohort with a minimum of 2-year follow-up. Patients were asked about their overall satisfaction on a visual analogue scale (VAS) of 1–10 (10 being most satisfied) and whether they had a "forgotten hip", with the question: "Do you feel as though you can totally forget about your hip replacement (as though you had not had a replacement)?". Where sounds, sensations or instability was experienced the patients hip position at the time of event and exact details of the event were documented.

Statistical analyses

Basic demographic data were summarised and presented using simple descriptive statistics where appropriate, and after assessing for normality for continuous data (Shapiro–Wilk test).

Patients were grouped according to whether or not they reported post-operative sounds on the returned questionnaire. Univariate analyses were performed first for potential predictor variables for post-operative. Continuous variables (age at procedure, BMI, native femoral head diameter, shell diameter, socket anteversion and inclination) were assessed for normality (Shapiro–Wilk test) and variance (Brown–Forsythe test), and appropriate comparisons of mean/median difference between groups were performed (Student *T* test or Wilcoxon–Mann–Whitney test). Categorical variables (gender, ASA, implanted head size, forgotten hip question) were summarised as 2×2 tables, and a Pearson Chi-square test for difference in proportions was performed for each, along with calculation of relative risk ratios where appropriate.

A binomial regression analysis for reported post-operative sounds was performed. All potential predictor variables were included in the initial model, and non-significant terms removed in a step-wise fashion until the final model included significant terms.

It is difficult to know whether the non-responders to the questionnaire represent an outlying group when considering the comparisons and analyses we have performed in trying to determine the potential predictor variables for post-operative sounds in CoC THA. Clinic review letters in the non-responders were reviewed for any suggestion of reported sounds (Fig. 1).

Statistical analyses were performed using Analyse-it Standard Edition v4.65. Statistical significance was set to $p < 0.05$.

Results

Demographics

Out of 246 ceramic on ceramic uncemented THA in 225 patients (13 bilateral staged, 8 bilateral simultaneous), we received 172 completed questionnaires (70% return rate). In the responders, the mean age at surgery was 53 years (95% CI 51–54; range 23–76). The male-to-female ratio was 72:100. The mean follow-up post-surgery to completion of the questionnaire was 40 months (95% CI 38–41; range 23–58). One patient only had 23-month follow-up (aim was for 2 years minimum).

Reported sounds

Forty-two (24%) patients reported sounds from their THA. The nature of sounds described are summarised below. In patients reporting sounds, the most commonly reported sound was a "squeak" (45%) followed by a "clunk" (24%), or a "click" (14%).

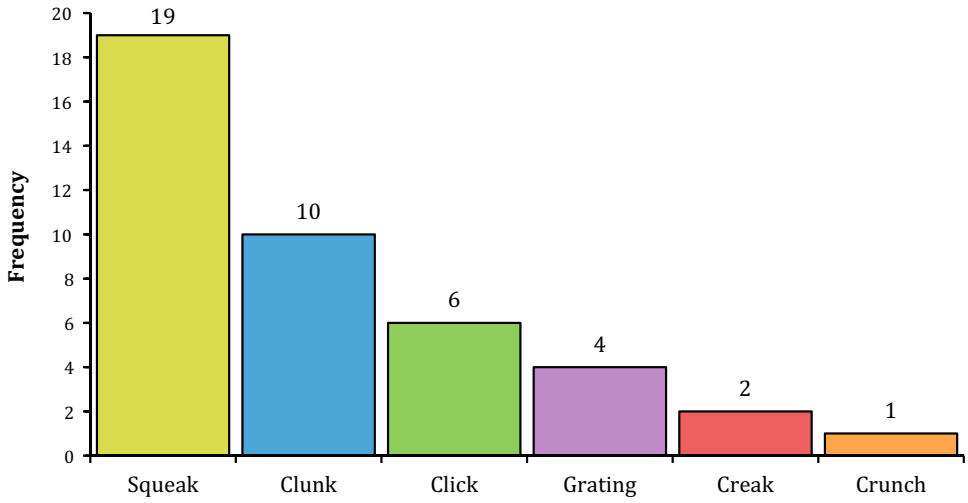

Fig. 1 Graph showing the patient reported sound from their CoC THA

In patients experiencing a "squeak", 17 out of 19 (90%) patients reported this to occur during flexion. In those with a "clunk", 5 out of 10 (50%) reported this in extension and 3 (30%) in flexion.

Patient satisfaction

Whilst the overall reported satisfaction was high in patients reporting sounds and in those who did not [median = 9 (8–10) vs. 10], there was a small yet statistically significant difference in median satisfaction (median difference = − 1, 95% CI − 2 to 0, $p < 0.001$).

Forgotten hip

Overall, 120 (70%) patients out of the 171 questionnaire respondents (1 response left blank out of the 172 returned questionnaires) reported "yes" to the forgotten hip question. Figure 2 demonstrates the relative percentages of patients with a forgotten hip according to whether they had reported sounds.

In the group with reported sounds, 48% responded "yes" to the forgotten hip question compared to 78% in the group with no reported sounds. The relative risk ratio of having a forgotten hip in patients not reporting sounds compared to that in patients reporting sounds was 1.7 (95% CI 1.3–2.5, $p = 0.0002$). Therefore, patients were more likely to feel as though they had forgotten about their hip replacement if they did not experience sound generation from their hip replacement.

Predictors for sounds

Univariate analyses of potential predictor variables for patients reporting sounds were performed, as summarised in Table 1. Compared to those not reporting sounds after CoC THR, patients reporting sounds were found to have less acetabular version (mean = − 3°, 95% CI − 6 to − 0.6, $p = 0.0172$). The relative risk of reporting sounds was lower in those receiving a 28-mm head compared to those with a 36-mm head (RR 0.37, 95% CI 0.14–0.89, $p = 0.024$). All other variables were not found to be statistically significant.

A binomial regression model for reported sounds was created using all predictor variables, and non-significant variables removed sequentially. The final model was statistically significant ($p = 0.011$). The odds ratios are summarised in Table 2. Age at surgery and version were found to significantly contribute to the model, but implanted head size did not.

Non-responders

We reviewed the clinic letters from the 76 patients who did not return questionnaires. Only 1 patient reported squeaking and 2 reported creaking from their hips.

Complications

Out of the 172 responders, there were two dislocations (neither revised), one deep infection [successful

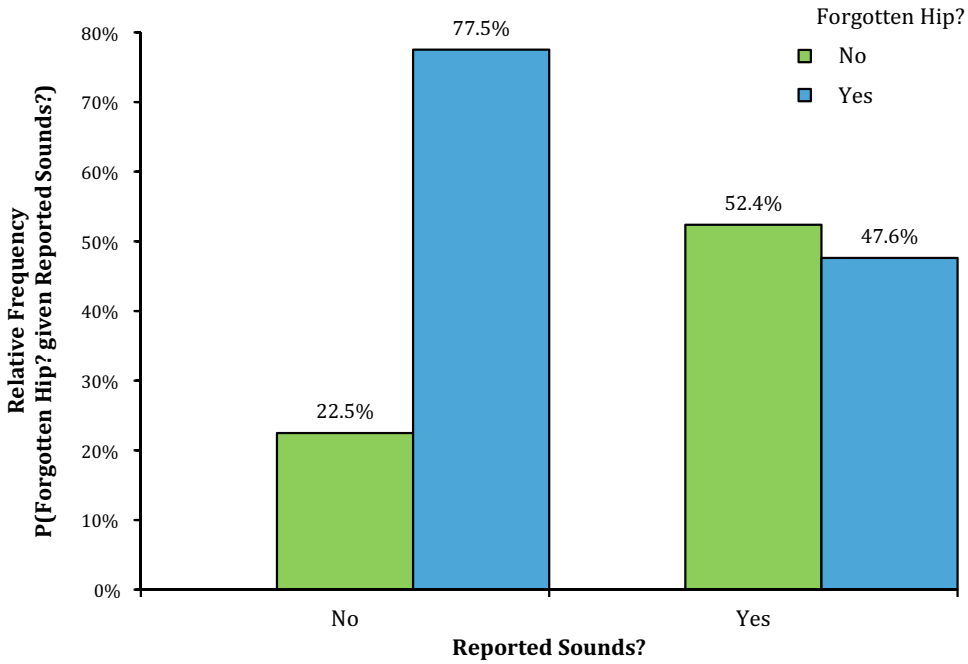

Fig. 2 Graph showing whether patients reported they had a forgotten hip and whether their hip was noisy

Table 1 Summary comparisons for potential predictor variables of reported sounds after CoC THR

	Sounds (42)	No sounds (130)	Difference	*p* value
Age at surgery (years)	51 (48–56)	55 (53–56)	−3 (−5 to 0.4)[b]	0.084[c]
BMI	30 (26–31)	27 (26–28)	1.5 (−0.5 to 3.5)[b]	0.134[c]
Native femoral head size (mm)	47 (46–49)	47 (46–48)	0.3 (−1 to 1.7)[a]	0.718[d]
Acetabular anteversion (°)	16 (13–18)	19 (17–20)	−3 (−6 to −0.6)[a]	**0.017**[d]
Inclination (°)	42 (40–44)	41 (40–42)	1 (−2 to 4)[a]	0.507[d]
Shell size (mm)	53 (52–54)	52 (52–54)	0 (0–2)[b]	0.182[c]
Gender				
Male	19	53		0.609[e]
Female	23	77		
ASA				
1	12	56		0.194[e]
2	27	63		
3	3	11		
Head size				
28 mm	4	34	RR (sounds 28 vs. 36)	**0.024**[e]
36 mm	38	96	0.37 (0.14–0.89)	

$p < 0.05$ are indicated in bold

[a]Mean (range)

[b]Median (range)

[c]Wilcoxon–Mann–Whitney test for median difference

[d]Student *T* test for mean difference

[e]Chi-square test

debridement and retention of implants (DAIR) procedure] and one patient had a femoral nerve neuropraxia that persisted at 39 months (overall satisfaction 9/10). No patients experienced a ceramic fracture. At the latest follow-up (questionnaires returned at a mean of 40 months; range 23–58 months), no implants had been revised.

Table 2 Binomial regression model for patient reported sounds

	Odds ratio	Wald 95% CI	*p* value
Age at surgery (years)	0.96	0.92–0.99	**0.043**
Anteversion	0.94	0.88–0.99	**0.021**
Implanted head size			
28 mm	1.00		0.149
36 mm	2.26	0.69–7.30	

Non-significant predictor terms were eliminated in a step-wise fashion

$p < 0.05$ are indicated in bold

Discussion

Squeaking is a well-documented phenomenon associated with CoC bearings in THA. Several methods of noise generation have been proposed which are well summarised in the review by Levy et al. [15]. Patient, implant and surgical factors have all been implicated; however, the exact mechanism is not yet fully understood.

CoC bearing surfaces have become popular due to their good wear properties in vitro [1–3]. As patients' demands increase and THA is performed in younger patients, a hard bearing surface with minimal wear is favourable for implant survivorship. With less third body wear and less osteolysis in vitro compared to other bearing surfaces, the CoC bearing gained in popularity. Ceramic fracture was a concern with the first generations of ceramics, but with modern third- and fourth-generation ceramics, the rate of fracture is now reported at 0.19–0.3%, because of the improved materials and manufacturing techniques [16, 17].

Recently the proportion of CoC bearings in uncemented THA has decreased from a high of 44.7% in 2011 to 28.8% in 2015 [13]. This decline in the use of CoC is felt to have been partly attributed to patients reporting dissatisfaction due to squeaking from their THA. This in turn has led surgeons to report on the phenomenon and move towards quieter bearings. The trend seen may also be a result of the improved survivorship seen in uncemented THA using the less expensive ceramic on polyethylene (CoP) bearing compared to CoC [95% CI; 95.51% (3.98–5.06) vs. 94.31% (4.97–6.50)] at 13 years [18].

Reported rate of sounds

In our series, we report a rate of squeaking of 11% and all noises of 24%. This is much higher than Lau et al. [19] who had no squeaks in their series of 126 CoC THA, but less than half of the 24.6% reported by Owen et al. [20] in their series of 69 hips. Our questionnaires directly asked patients about squeaking and noise generated from their hips, as did the Owen et al. [20] study with its high incidence of squeaks. It is suggested that direct questioning to patients about noises in their THA leads to a higher reported incidence of squeaking, compared to studies in which the joint noises were volunteered by the patients. Owen et al. [21] also published a meta-analysis estimating the incidence of squeaks in CoC THA. A total of 545 hips squeaked out of 15,131 giving an incidence of 4.2%. They specifically reviewed in the study method if patients were directly asked if their hip squeaked or if it was self-reported. The incidence of squeaking in self-reporting studies was 1.2% (95% CI 0.6–2.6), compared to direct questioning which was 4.5% (95% CI 3.5–5.8), which was significant ($p = 0.002$) [21].

Predictors of sound generation

Timing

The onset of squeaking post-THR has been reported from 14 to 40 months, and our mean follow-up post-surgery for our study questionnaires was 40 months (95% CI 38–41; range 23–58) [7, 21–23]. This would suggest that we should have identified all the patients who have experienced a squeak and the timing of our follow-up could account for our high rate of noisy hips, with the onset being acute to arrival of the questionnaire, and therefore a new concern for the patient and at the forefront of their mind.

Following THA, squeaks in the early post-operative period are shown to decrease in frequency and incidence over the lifetime of the implant [21]. In their meta-analysis Owen et at [21] found patients with follow-up of > 100 months had a lower incidence of squeaking (2.4%) (95% CI 1.4–4.6) compared to those with < 100 months follow-up (4.6%) (95% CI 3.5–61), although this was not statistically significant ($p = 0.82$). At 9.5 years after the primary procedure, one study found 15% of squeaking hips stopped and overall the squeaking phenomenon was well tolerated [7]. In another study, 13 out of 14 initially squeaking hips had stopped squeaking at an average follow-up of 69.5 months [24]. In the long-term follow-up series by Kim et al. [25], squeaking frequency and pitch decreased in 40% of their patients over time.

These findings support a more considered, conservative approach to revision for a noisy hip, with an extended period of observation and reassurance for the patient. We are not aware of any episodes of implant failure as a result of a squeaking hip and several studies have not found an association with squeaking and pain, which may be a more reasonable consideration for revision surgery [6, 8, 26].

Age

In our series, younger age was significantly associated with having a "noisy" hip (OR 0.96, $p = 0.043$), although the

clinical significance of this may be negligible. We found BMI, implanted head size, ASA and acetabular cup inclination were not associated with squeaks. Sexton et al. [7] found patients with a squeaking hip were 5 years younger than those with silent hips (60 years vs. 65 years; $p < 0.001$), but did not find a difference with BMI. Kuo et al. [27] similarly found BMI did not influence squeaks but a younger age did [39.5 (23–60) years vs. 52.2 (21–76) years; $p = 0.01$]. In contrast, in their meta analysis and systematic review Stanat and Capozzi [8] did not find age was a significant risk factor for squeaking, but increasing BMI was ($p = 0.03$).

Younger patients are more active and put higher demands on their THA, meaning more cycles and loading of their hip than an older patient. Hence a movement generated phenomenon, such as a squeak, may be expected to occur more frequently. Indeed Sexton et al. [7] found that the activity subgroup score of the Harris Hip Score (HHS) was significantly higher in squeaking hips [median 14 (5–14)] when compared with silent hips [median 12 (2–14), $p = 0.009$]. In a young active cohort of patients Restrepo et al. [6] found the incidence of squeaking to be 6%. Patients with squeaking had a mean age at the time of surgery of 46 years compared to 49.9 years for quiet hips, though this was not statistically significant. This was not replicated in the Lau et al. [19] series of 126 CoC THA, which had no squeaks after an average follow-up of 12.1 years in patients with an average age of 39.6 years at the time of surgery.

From the current literature, we are unable to determine whether age is a significant risk for squeaking in THA, with contrasting results. In any event, there is certainly no evidence to suggest that older patients are at higher risk than their younger counterparts.

Implant and patient positioning

Positioning of the acetabular implant had been identified as a risk factor for a squeaking THA. In our series, patients with sounds were found to have less anteversion than those not reporting sounds, by a median of 3 degrees (95% CI 0.6–6, $p = 0.017$) though this difference was not statistically significant. A review article concluded that high or low acetabular anteversion is associated with squeaking suggesting neck to rim impingement as the mechanism for squeaking [28]. Walter et al. [23] found that the variance of anteversion in squeaking hips was 6 times greater than non-squeaking hips, defining 15–35 degrees as acceptable ($p < 0.01$; 95% confidence interval, 2.1–16.5). Their squeaking hips had a mean anteversion which was lower than the non-squeaking hips (25° vs. 26°). This supports the trend in our findings, with our "noisy" hips having a mean anteversion at the lower end of Walter et al.'s [23] lower limit.

Patients in our series reported that the noise was generated in predictable and reproducible positions. Flexion (bending) was associated with a "squeak" in 17 out of the 19 squeaking hips (90%). Half of the patients who experience a "clunk" do so in flexion (5 out of 10) and 30% in extension (walking) (3 out of 10). Walking, bending and standing from sitting have been proposed as functions which induce squeaks [6, 29, 30]. Restrepo et al. [6] found walking was associated with squeaking in 38% of patients and bending in 21%, with Walter et al. [23] reporting squeaking in 47% of patients when they were bending over and 24% when walking. The cause for the noise generated, as already stated, is multifactorial, and the different positions of the hip could be causing impingement, edge loading and changes in the lubrication of the hip throughout loading and movement of the hip.

Patient satisfaction

We found a higher incidence of patients reporting sounds from their CoC THA than has been previously published. In our series, patients were overall satisfied with their THA, with a median satisfaction score of 9 for "noisy" hips and 10 for "quiet" hips, scored on a visual analogue scale of 1–10. Patients with a "noisy" THA were significantly less satisfied with their THA by a median difference of − 1 (9 compared to 10) (95% CI − 2 to 0, $p < 0.001$). Despite this, they still had high overall satisfaction levels with a very low complication rate and no revisions were undertaken within our follow-up period.

Matar et al. [31] reported that some patients had found their squeaking intolerable and pursued revision surgery. Although we did not find such extreme feelings in our patients, we found that patients with "quiet" hips were 1.7 times (95% CI 1.3–2.5, $p = 0.0002$) more likely to feel as though they could forget that they had a THA done, compared to patients with a "noisy" hip.

In their large series of 2406 THAs, Sexton et al. [7] found no significant differences in patient satisfaction (VAS) or function (Harris Hip Score) with squeaking and silent THAs. Similar outcomes were found in a smaller series by Kim et al. [25] both at over 10-year follow-up. High Oxford Hip Scores (OHS) were reported by Salo et al. [32] for both squeaking and silent hips; however, there was a statistically significant higher average score in the silent hips (43 vs. 46.5, respectively). Similarly in our study although statistically significant, these results may not be appreciable clinically with the minimum clinical difference in OHS suggested at 3–5 points [33].

Revision for sounds

The long-term consequences of noise generation on implant survivorship are unknown. In a meta-analysis by Owen et al. [21], the rate of revision for patients reporting

squeaking was estimated at 0.2%; although it is conceded, this is probably underreported. A similar revision rate of 0.26% has been reported in a previous meta-analysis by Stanat and Capozzi [8]. Similarly Restepro et al. [6] reported only 9 out of 1486 THA were revised for squeaking. These published studies and meta-analyses support the feeling that squeaking is a benign process, with such a low rate of revision for squeaking in the published literature. Unfortunately, the UK NJR does not collect information specifically regarding revision for a "noisy" hip.

In our relatively short-term follow-up, none of the hips were revised for any cause. It is therefore difficult to support or justify a revision procedure purely for CoC noises, given that noise generation does not seem to be linked to poor patient satisfaction, at least in the short term.

Retrieval analysis

Walter et al. [34] analysed 12 retrieved squeaking implants and compared to controls. All the retrieved implants had evidence of edge loading, but no chipping or fractures were seen. The volumetric wear analysis demonstrated that there was 45 times greater wear seen in the noisy implants compared to controls. It is unclear whether the wear is a result of the squeaking or the squeaking is a consequence of the wear. This has significant implications for patients with squeaking as increased wear may lead to earlier failure; however, this has not yet been demonstrated clinically.

In the retrieval analysis by Matar et al. [31], they again found edge loading in all 7 of their bearings, with 5/7 demonstrating neck rim impingement. This type of impingement may predispose the ceramic bearing to chipping or fracture and has been suggested as a cause for squeaking. Toni et al. [35] found that aspiration of noisy CoC THA demonstrated ceramic particles in 10 patients. In contrast 5 well performing, silent CoC bearing THA did not have any ceramic particles detectable. The particles detected were more in keeping with fractured ceramic than wear particles and this supports the findings of Abdel et al. [36] who reported 4 patients with painful squeaking hips who were found to have a fractured ceramic liner at the time of revision.

These retrieval analyses suffer from bias, as the patients underwent surgery to retrieve the bearings in revision procedures, suggesting they had severe symptoms to warrant a further procedure. In the Walters et al. [34] study, they were all retrieved early, within 2 years. In our study and others, patients with noisy bearings have been largely satisfied with good function and therefore these bearings have not been analysed and my not be represented by the retrieval studies.

Long term implications

At 10 years Kim et al. [25] reported a squeaking rate of 21.3%, but did not find squeaking correlated with the clinical results or the survival of the prosthesis. Similarly Cheviollotte et al. [37] described their follow-up of squeaking hips to be an isolated phenomenon at 10 years without any consequences.

The long-term psychological implications for patients with well-functioning but noisy hips is lacking in the current literature. Studies typically report patients to be intolerant of the sounds or embarrassed about the sounds they are experiencing which hinders their activities [24, 25]. To our knowledge, there are no studies which have looked at this area subjectively.

From the current literature, it appears that noisy hips without pain do not have a clinically significant impact on patient satisfaction or function and can be observed. This has been demonstrated at 10 years with very low revision rates reported for squeaking. A painful noisy hip should be investigated thoroughly for component positioning and potential fracture.

Limitations

Our study does have some limitations that we recognise. This is a retrospective study using a questionnaire that has not been validated, although use of VAS is a well-recognised technique. The patient reported outcomes we wished to analyse were not included in any validated questionnaires at the time of our data collection. Our patient series is not adequately powered to determine the revision rate and we have relatively short-term follow-up at a mean of 40 months (95% CI 38–41, range 23–5. For the 30% of non-responders, we were only able to determine their symptoms from their clinic letters and were unable to ask them directly about the sensations and sounds from their THA, meaning we do not truly know whether they had sounds or not.

Conclusion

We have identified a relatively high rate of squeaking in this series. We have also found an inverse relationship between "noisy" hips and satisfaction levels, with a higher rate of having a "forgotten" hip in those with a "quiet" hip. A "noisy" hip seems to be associated with younger age at surgery and less anteversion of the implanted acetabular cup. However, clinically the impact of a noisy hip is likely to be negligible with overall high satisfaction rates. Together with our study's findings and the overall current evidence base in this area, we would propose a considered approach to revision surgery purely for a noisy CoC hip joint, and

recommend observation as far as possible where patients are otherwise functioning well.

As the reported THA survival rate for CoC is not significantly better than CoP bearings over 13 years and the length of survivorship data of CoXLP with cross-linked polyethylene is now up to 28 years, the pendulum is seemingly swinging towards CoXLP as the best available bearing couple for younger patients [18, 38]. Justification for the use of CoC bearings becomes even more difficult considering the higher costs (compared to CoP or CoXLP), when considering the current difficult economic climate of many healthcare systems.

This paper has identified an important relationship between noisy hips and patient satisfaction that is hard to ignore in this era of increasing patient expectations from joint arthroplasty. Clearly, further research is required in the form of a randomised trial to understand this relationship further, but in the meantime, we feel that there is sufficient evidence to justify limiting the implantation of CoC bearing couples in our department.

Compliance with ethical standards

Conflict of interest Barrow has nothing to disclose. Divecha has nothing to disclose. Panchani has nothing to disclose. Boden has nothing to disclose. Chitre has nothing to disclose. Gambhir reports an Educational contract with Johnson and Johnson. Porter reports he is Medical Director of the National Joint Registry of England and Wales (NJR), Chairman of the NJR Editorial Board and Past President of the International Society of Arthroplasty Registers (ISAR). Board reports grants and personal fees from DePuy Synthes, personal fees from Springer, outside the submitted work; he is Associate Editor of Hip International and a Research Committee Member for British Orthopaedic Association.

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