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Case report

Ceramic-on-ceramic total hip arthroplasty: Is squeaking related to an inaccurate three-dimensional hip anatomy reconstruction?

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ABSTRACT

Many factors were incriminated in the squeaking generation in ceramic-on-ceramic total hip arthroplasty (THA), including the cup positioning and design. However, the influence of the stem orientation has not been investigated and the true three-dimensional hip anatomy has never been compared to the contralateral healthy hip. Three patients, who underwent unilateral ceramic-on-ceramic THA, complained of squeaking. CT-scans were performed to compare the true three-dimensional hip anatomy to the contralateral healthy hip. All patients presented evidence of posterior neck-rim impingement with a two-fold increase in the global anteversion (above 75°) comparatively to the healthy hip. The excess of anteversion was on the cup side in 2 cases and on the stem side in 1 case. We conclude that squeaking in ceramic-on-ceramic THA could be related to a poor accuracy of 3D hip anatomy reconstruction which generated a posterior impingement and subsequent anterior edge loading because of excessive global anteversion.

1. Introduction

There is a rising concern about squeaking in ceramic-on-ceramic total hip arthroplasty, with an incidence ranging from 0.5% to 20% [1–4]. Many factors have been incriminated such as edge loading, ceramic fracture, third body particles [1] and components malposition. Walter et al. [2] reported that 65% of squeaking patients were not in a safe range of 25° ± 10° cup anteversion and 45° ± 10° cup inclination. Conversely, other authors [3,4] found no major cup malpositioning in squeaking patients. However, at the time of revision, all their squeaking patients showed evidence of posterior neck-cup impingement, suggesting components malposition.

All these authors used a so-called safe zone for component positioning with an optimal goal of 45° cup inclination and 15° cup anteversion [5]. However, the natural acetabular and femoral anteversion angles in primary osteoarthritis had a wide range of variation, (0 to 50°) [6] suggesting that a 15° cup anteversion may be too low or contrarily excessive, depending on the patient hip anatomy before surgery. Therefore, despite the fact that a patient is within this safe zone, impingement may occur because the patient 3D anatomy is not restored. This hypothesis is suggested by many reported studies [7–10] which showed that the impingement risk was minimal when the components were implanted with the same anteversion angles than the natural values. We analyzed the three-dimensional hip anatomy in three squeaking patients, who underwent unilateral THA, in order to compare the replaced hip to the contralateral healthy hip.

2. Cases report

Three patients (2 males, 1 female), who underwent alumina ceramic-on-ceramic total hip arthroplasty (trident cup, 2 cemented DEDICACE stem and one cementless ABG stem, Stryker) complained of a squeaking. The femoral head diameter was 32 mm in 2 cases and 28 mm in 1 patient. The mean age was 61.3 (56 to 68) years and the body mass index was 22.3 kg/m^2 (19.4 o 27.8) (Table 1). All the patients presented immediately after surgery a reproducible loud squeaking at each step when walking, at the end of the stance phase as the hip was fully extended. Patients accepted to perform a CT-scan to assess the three-dimensional hip anatomy using a specific software Hip-Plan [11]. The following parameters were assessed: the femoral offset, the height of the head femoral center from the top of the great trochanter, the coordinates of the hip rotation center and the anteversion values.

The same measurements were performed on the healthy contralateral hip; in order to compare the three-dimensional hip anatomy between the replaced hip and the natural healthy

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Table 1
Clinical data of the squeaking patients.

Case	Sex	Age	Height (cm)	Weight (kg)	BMI	Dislocation
1	M	68	180	90	27.8	No
2	F	56	170	56	19.4	No
3	F	60	160	50	19.5	No

BMI: body mass index.

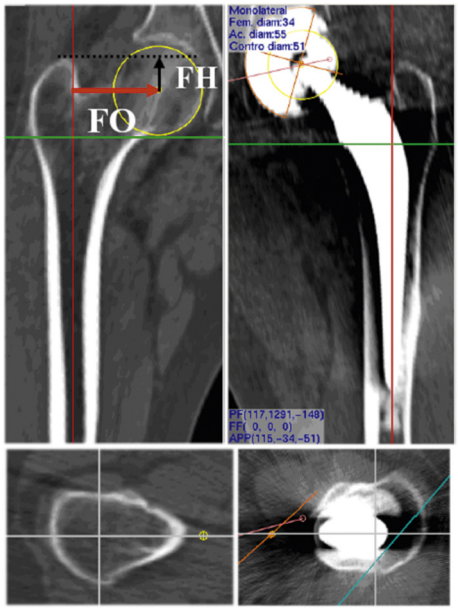

Fig. 1. The femoral anteversion, the femoral offset and the height from the top of the great trochanter to the femoral head center were measured and compared to the natural values on the contralateral side.

contralateral hip (Figs. 1 and 2). The true three-dimensional limb length discrepancy (LLD) was determined.

In the 3 squeaking patients, high values of the cup and the stem anteversion angles were found. These values were significantly increased (2 folds) in comparison to the contralateral non-replaced hip (Table 2). Indeed, the mean stem anteversion value was 36.3° ± 12.9°, increased by 21° ± 15° in comparison to the contralateral side. The mean cup anteversion angle was 42 ± 3.6°,

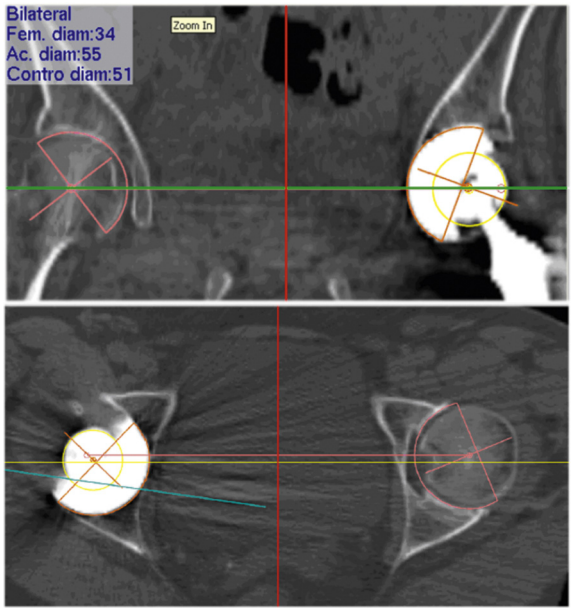

Fig. 2. The acetabular anteversion and the coordinates of the hip center of rotation were measured on the replaced hip and the contralateral healthy hip.

increased by 19.3 ± 9° in comparison to the contralateral side. Thus, the global anteversion angle was 78.3° ± 9.7°, increased by 43.6° ± 11° in comparison to the contralateral side, corresponding to a 2 fold increase (Fig. 3). All patients presented on the CT-scan, evidence of posterior neck-rim impingement (Fig. 4). The cup abduction angle was found to be extremely high in one case (72°). In two cases, the X-rays showed that the liner was not fully seated inside the metal back.

The 3 patients had a lengthening of about 16 mm ± 6 on the squeaking side (8 to 20 mm). The femoral offset was increased by 15 mm (44%) in one case and decreased by 8 mm (19%) in one case (Table 3). The hip rotation center was excessively shifted medially (13 mm) and posteriorly (5 mm) in one patient. One patient was revised and the retrievals showed evidence of anterior edge loading with stripe wears (Fig. 5). The squeaking disappeared in this patient but remained in the 2 other ones.

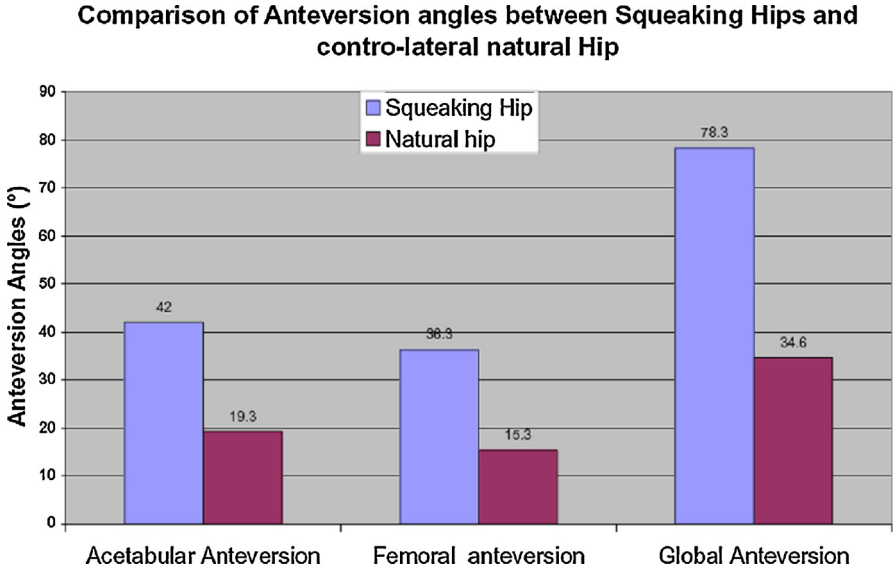

Fig. 3. Comparison of the anteversion angles between the squeaking hips and the controlateral natural hips.

Table 2
The anteversion values were increased for the squeaking replaced hip, comparatively to the contralateral healthy hip.

Case	Acetabular anteversion		Femoral anteversion		Global anteversion	
	Squeaking hip	Contralateral healthy hip	Squeaking hip	Contralateral healthy hip	Squeaking hip	Contralateral healthy hip
1	45	24	31	21	76	45
2	38	25	51	13	89	38
3	43	9	27	12	70	21

Table 3
The three dimensional values of the coordinates for the femoral head center and the hip center of rotation. Comparison between the replaced squeaking hip and the contralateral healthy hip. A poor anatomy restoration was found in the squeaking hips. Negative values means lower than the great trochanter (femoral hip center), or posterior relatively to the pubic symphysis (hip rotation center).

Case	Femoral head center (mm)				Hip center of rotation (mm)					
	Femoral offset		Femoral height		Cranio-caudal		Medio-lateral		Antero-posterior	
	THA	Natural	THA	Natural	THA	Natural	THA	Natural	THA	Natural
1	42	50	−4	−15	8	13	90	89	−47	−48
2	44	45	−2	−17	14	13	82	95	−48	−43
3	49	34	−6	−6	15	6	87	91	−57	−56

THA: total hip arthroplasty.

3. Discussion

The main finding of our study was that all the patients who squeaked when walking had the components implanted with an excessive anteversion generating consequently a posterior neck-rim impingement. This is consistent with the results previously reported but these studies did not find a significant difference in the average cup anteversion between the squeaking group and the non-squeaking group [2,12].

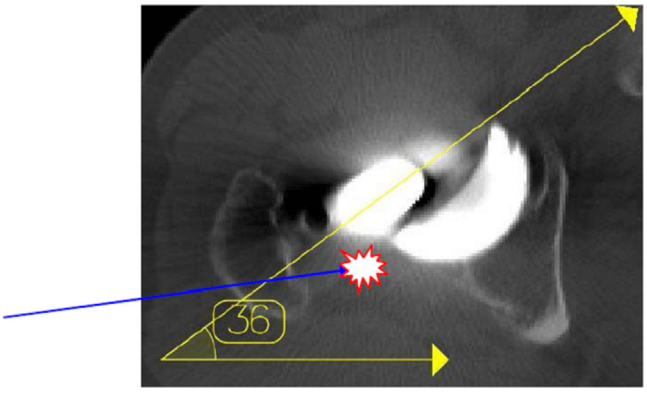

Fig. 4. A posterior impingement was identified on the CT-scan in the squeaking patients.

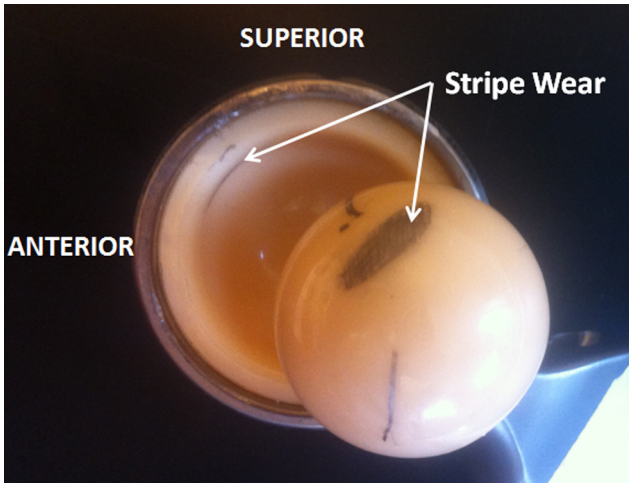

Fig. 5. The revised patient showed evidence of anterior edge loading with anterior stripe wear marked with pencil.

The current study has some strengths. Firstly, each patient was compared to himself using the contralateral healthy limb, thus avoiding the bias introduced by the selection of a control group. Secondly, a three-dimensional assessment of the hip anatomy was performed, that is more accurate than plain X-rays, especially for measuring the cup anteversion and the femoral offset. Finally, both the acetabular and the femoral anteversion angles were analyzed, contrary to most of the previous studies that did not measured the stem anteversion that may promote the squeaking despite a normal cup anteversion. On the other hand, this study has some limitations. Firstly, only 3 patients were analyzed considering squeaking is extremely rare. Secondly, there was no available CT-scan of the replaced hip before surgery, but all patients had a contralateral hip that was used to make a comparison with the replaced hip. Finally, all patients had the same acetabular component which has been reported to generate the highest squeaking rate in the literature. In contrast, the components malposition was highly significant and it probably triggered the impingement then the edge loading and finally the squeaking. Indeed, the squeaking requires the combination of 2 factors: the lubrication alteration and increased contact constraints. Such conditions may be obtained with an edge loading that could be the consequence of a third body (alumina fracture) or decoaptation due to impingement [13]. In our study, the squeaking was generated at each step during the hip extension at the end of the stance phase, when a posterior impingement is likely to occur, generating consequently a decoaptation and so an anterior edge loading [14]. This is clearly supported by the retrievals analysis which showed anterior stripe wear. In two cases, the liner was not fully seated inside the metal back, making the posterior impingement more likely to occur. This may explain why the squeaking is more frequent with some ceramic-liners like the trident cup, which are technically more difficult to implant well seated in the shell [15,16].

4. Conclusion

The squeaking in ceramic-on-ceramic THA could be related to a poor accuracy of the 3D hip anatomy reconstruction which generates a posterior impingement and so anterior edge loading because of an excessive global anteversion. The 3D anatomy of

the squeaking hip should be analyzed with a CT-scan and the hip revision has to be strongly considered.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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