

Mid-term outcomes of uncemented or cemented arthroplasty revision following metal-on-metal total hip arthroplasty failure: a retrospective observational study

Journal of International Medical Research
0(0) 1–9

© The Author(s) 2020

Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/0300060520932051

journals.sagepub.com/home/imr



Zhao Chen^{1,*}, Wenli Chen^{2,*}, Weiguang Yu³,
Mingdong Zhao⁴ , Jinluan Lin⁵,
Chaoming Zhou⁶, Hui Chen⁷, Junxing Ye⁸,
Xianshang Zeng³ and Jintao Zhuang⁹

Abstract

Objective: To retrospectively compare the mid-term outcomes of uncemented or cemented total hip arthroplasty (THA) revision for prior primary metal-on-metal (MoM) THA failure.

Methods: Data from 278 patients (278 hips) who underwent uncemented THA (UTHA) or cemented THA (CTHA) for prior primary MoM-THA failure from 2006 to 2016 were retrospectively analysed. Follow-up was performed 6 months, 1 year, 2 years, and then every 2 years

¹Department of Pediatric Orthopaedics, Fujian Children's Hospital, Fuzhou, Fujian Province, China

²Department of Neurosurgery, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China

³Department of Orthopaedics, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China

⁴Department of Orthopaedics, Jinshan Hospital, Fudan University, Shanghai, China

⁵Department of Orthopaedics, The Affiliated hospital of Fujian Medical University, Fuzhou, Fujian, China

⁶Department of Pediatric Surgery, Fujian Maternity and Child Health Hospital, Affiliated Hospital of Fujian Medical University, Fuzhou, Fujian, China

⁷Department of Pediatric Orthopaedics, Fujian Maternity and Child Health Hospital, Affiliated Hospital of Fujian Medical University, Fuzhou, Fujian, China

⁸Department of Orthopaedics, The Third People's Hospital of Wuxi, Jiangsu Province; The Affiliated Hospital of Jiangnan University, Wuxi, Jiangsu, China

⁹Department of Urology, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China

*These authors contributed equally to this work.

Corresponding author:

Mingdong Zhao and Xinchao Zhang, Department of Orthopaedics, Jinshan Hospital, Fudan University, Longhang Road No. 1508, Jinshan District, Shanghai City 201508, China.

Emails: fzch0321@163.com; xianshangzh@126.com; brianzg86@163.com



after conversion. The mean follow-up time was 96 months (range, 64–128 months). The primary endpoint was the modified Harris hip score (HHS). The secondary endpoint was the major orthopaedic complication rate.

Results: The HHS showed significantly greater differences in the CTHA than UTHA group 12 months after conversion. From the 12th month after conversion to the final follow-up, CTHA yielded better functional outcomes than UTHA. There were significant differences between the UTHA and CTHA groups in the rates of re-revision (14.4% vs. 4.9%, respectively), aseptic loosening (17.3% vs. 6.8%, respectively), and periprosthetic fracture (11.5% vs. 3.9%, respectively).

Conclusion: CTHA has more advantages than UTHA in terms of improving functional outcomes and decreasing the major orthopaedic complication rate.

Keywords

Uncemented, cemented, total hip arthroplasty, metal-on-metal, complication, revision surgery

Date received: 1 January 2020; accepted: 14 May 2020

Introduction

Bearing surfaces provided by metal-on-metal total hip arthroplasty (MoM-THA) became increasingly prevalent, particularly in the context of the ageing population, in earlier decades.^{1,2} In recent years, however, the use of MoM-THA has sharply declined because of the reported low 10-year survival rate and high failure rate, which are associated with several issues including adverse reactions to metal debris (ARMDs), aseptic loosening, and infection.^{1,3} Failure after MoM-THA is well recognised, has various causes, and frequently requires surgical revision.⁴ Failure that occurs secondary to MoM wear tends to be of particular concern among physically active individuals.⁵ Although MoM bearings have fallen out of favour as a result, orthopaedists continue to struggle with this issue of revision burden.² Poor bone stock may be attributed to the substantial bone and soft tissue destruction caused by an ARMD, which is powerfully implicated in the pathophysiology of MoM-THA failure and contributes

to the substantially high revision rate as well as the rapid time to failure.²

This high MoM-THA-related failure rate may also contribute to the increased use of uncemented THA (UTHA) or cemented THA (CTHA).⁶ A few studies^{5,6} have assessed complications due to conversion of MoM-THA to the use of uncemented or cemented femoral components (UTHA or CTHA). Interest in CTHA has increased during the last decade, with several studies showing higher Harris hip scores (HHSs) and fewer orthopaedic complications in CTHA than in UTHA.^{7,8} However, other studies have demonstrated no significant differences between the two techniques.^{9,10} Furthermore, there are concerns that longer-term outcomes of UTHA may not be as robust as those of CTHA in terms of reduced revision rates.¹¹ Additionally, highly selected patient populations are common in the published literature.^{2,12} Thus, the findings of these previous studies cannot be considered valid.

No definitive consensus exists on the mid-term outcomes of conversion from primary MoM-THA to UTHA or CTHA of

any cause.⁹ Given the lack of literature and minimal understanding of these types of conversions, we performed a retrospective study to assess the mid-term outcomes of conversion from primary MoM-THA to UTHA or CTHA.

Materials and methods

Study population

This retrospective study was approved by the Medical Ethics Committee of the Affiliated Hospital of Fujian Medical University, and the investigational review board waived the requirement for informed consent. An initial study cohort comprising 278 patients (278 hips) was identified from our joint registration database. All patients had undergone UTHA or CTHA revision because of prior primary MoM-THA failure from May 2006 to May 2016. The main reasons for revision were ARMD, aseptic loosening, infection, dislocation, and fracture. The inclusion criterion for the study was performance of a conversion procedure from primary MoM-THA (Zimmer Biomet, Warsaw, IN, USA) to UTHA or CTHA. The manufacturer details of the devices used in UTHA and CTHA are shown in Table 1. All conversion procedures were performed by three experienced orthopaedists (J.Y., J.L., and Z.C.) via a direct anterior approach as previously described.¹³ The main exclusion criteria were the lack of an MoM-bearing surface at the time of conversion, inadequate clinical data, active infection, dyskinesia, bone-related diseases, an inability to follow instructions, malignant tumours, an injury severity score of ≥ 10 , brain dysfunction of any cause within 6 months, pulmonary complications (e.g., re-intubation), cardiovascular complications (e.g., cardiac arrest, myocardial infarction), renal complications (e.g., insufficiency or failure), vascular cognitive impairment, a history of alcohol and/or drug abuse, a body mass

Table 1. Manufacturer details of UTHA and CTHA.

Patients, n	Stem	Cup
UTHA		
63	Corail ¹	Reflection uncemented ²
41	Filler3	Trident, ⁴ Iglloo3
CTHA		
62	Exeter ⁴	Exeter, ⁴ Elite, ⁴ IP/SP1 ⁵
40	Spectron EF ²	Contemporary, ⁴ Marathon ¹

¹DePuy, ²Smith & Nephew, ³Biotechni, ⁴Stryker,

⁵Waldemar LINK. UTHA, uncemented total hip arthroplasty; CTHA, cemented total hip arthroplasty.

index of $>40 \text{ kg/m}^2$, and an American Society of Anesthesiologists score of IV or V.

A standard protocol was utilised to obtain clinical and radiographic data. Follow-up was performed 6 months, 1 year, 2 years, and then every 2 years after conversion. The primary endpoint was the modified HHS. The secondary endpoints were the major orthopaedic complication rates. All patients underwent conversion to UTHA or CTHA at our medical centre and were assessed individually with the modified HHS at each follow-up. Imaging data were acquired at these same time points: anteroposterior radiographs of the pelvis and anteroposterior and lateral radiographs of the hip as well as computed tomography or magnetic resonance imaging if necessary. The occurrence of major orthopaedic complications was recorded for each patient during follow-up.

Statistical analysis

Between-group differences in the baseline data and main follow-up data were compared. Follow-up was calculated in days from the date of revision/conversion to the date of death or final follow-up, whichever occurred first. Revision was defined as complete removal of the endoprosthesis.²

Prosthesis loosening and endoprosthesis failure were judged based on prior descriptions.⁴ Continuous data are presented as mean \pm standard deviation. A t test was utilised to assess between-group differences if the data were consistent with assumptions regarding a normal distribution and homogeneity of variance. If not, the Wilcoxon rank-sum test was utilised. Categorical data are presented as frequency and percentage and were compared between groups using the chi-squared test or Fisher's exact test, as appropriate. All statistical analyses were performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). A two-sided *p* value of <0.05 was considered statistically significant.

Results

Based on our inclusion and exclusion criteria, 206 individuals (206 hips) undergoing

conversion from primary MoM-THA to UTHA or CTHA were identified for the final analysis in the study. The UTHA comprised 104 patients with a mean age of 65.12 ± 7.34 years, and the CTHA group comprised 102 patients with a mean age of 64.67 ± 8.71 years. The interval from primary MoM-THA to failure was 3.7 years (range, 1.1–5.7 years) in the UTHA group and 3.6 years (range, 1.3–6.2 years) in the CTHA group. At the time of analysis, the mean follow-up time from conversion was 96 months (range, 64–128 months) in the UTHA group and 96 months (range, 66–126 months) in the CTHA group. A study flow chart is presented in Figure 1, and the baseline data are shown in Table 2.

Primary endpoint

The mean HHSs after conversion are shown in Table 3. The mean HHSs in the

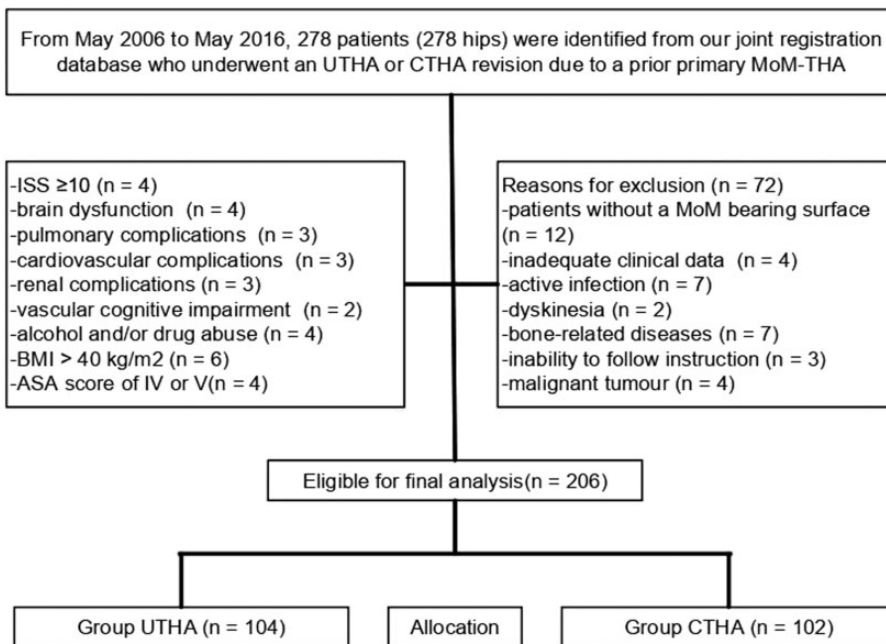


Figure 1. Study flow chart. UTHA, uncemented total hip arthroplasty; CTHA, cemented total hip arthroplasty; MoM-THA, metal-on-metal total hip arthroplasty; ISS, injury severity score; BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 2. Patient demographics and outcomes.

Variable	UTHA (n = 104)	CTHA (n = 102)	p-value
Sex, male/female	46/58	43/59	0.764
Age, years	65.12 ± 7.34	64.67 ± 8.71	0.206
BMI, kg/m ²	27.82 ± 6.95	28.32 ± 8.13	0.163
BMD	-3.54 ± 0.38	-3.57 ± 0.65	0.271
Side, left/right	54/50	53/49	0.996
Interval from primary MoM-THA to failure, years	3.7 (1.1–5.7)	3.6 (1.3–6.2)	0.105
Comorbidities			0.889
Hypertension	46 (44.2)	51 (50.0)	
Diabetes mellitus	25 (24.0)	24 (23.5)	
Heart disease	14 (13.4)	16 (15.6)	
Mechanism of injury			0.161
Traffic accident	33 (31.7)	27 (26.4)	
Falling	41 (39.4)	36 (35.2)	
Tamping injury	16 (15.3)	25 (24.5)	
Other	12 (11.5)	14 (13.7)	
ASA score			0.758
I	26 (25.0)	22 (21.5)	
II	52 (50.0)	57 (55.8)	
III	24 (23.0)	23 (22.5)	
Preoperative HHS	54.79 ± 14.92	55.88 ± 16.37	0.102
Follow-up, months	96.12 ± 32.15	96.31 ± 30.28	0.152

Data are presented as n, n (%), mean ± standard deviation, or median (range).

UTHA, uncemented total hip arthroplasty; CTHA, cemented total hip arthroplasty; BMI, body mass index; BMD, bone mineral density; MoM-THA, metal-on-metal total hip arthroplasty; ASA, American Society of Anesthesiologists; HHS, Harris hip score.

Table 3. Mid-term follow-up: functional outcomes.

HHS, year(s) after conversion	UTHA (n = 104)	CTHA (n = 102)	p-value
0.5	82.75 ± 5.13	83.12 ± 6.25	0.103
1	85.56 ± 6.24	87.18 ± 9.73	0.026*
2	86.19 ± 5.22	89.21 ± 6.50	0.029*
4	88.37 ± 6.91	90.15 ± 7.04	0.032*
6	84.82 ± 10.05	88.46 ± 8.51	0.021*
8	82.13 ± 16.75	86.42 ± 12.49	0.014*
Final follow-up	78.22 ± 17.36	85.91 ± 15.02	0.012*

Data are presented as mean ± standard deviation.

*Statistically significant values.

HHS, Harris hip score; UTHA, uncemented total hip arthroplasty; CTHA, cemented total hip arthroplasty.

UTHA and CTHA groups were 82.75 ± 5.13 and 83.12 ± 6.25 6 months after conversion, 85.56 ± 6.24 and 87.18 ± 9.73 12 months after conversion, and 78.22 ±

17.36 and 85.91 ± 15.02 at the final follow-up, respectively. The HHSs showed significantly greater differences in the CTHA than UTHA group 12 months

Table 4. Mid-term follow-up: prosthesis-related complications.

Variable	UTHA (n = 104)	CTHA (n = 102)	p-value
Re-revision	15 (14.4)	5 (4.9)	0.021*
Periprosthetic fracture	12 (11.5)	4 (3.9)	0.041*
Loosening	18 (17.3)	7 (6.8)	0.022*
Dislocation	14 (13.4)	11 (10.7)	0.556
Deep infection	5 (4.8)	2 (1.9)	0.259
Unbearable hip pain	5 (4.8)	3 (2.9)	0.488

Data are presented as n (%).

*Statistically significant values.

UTHA, uncemented total hip arthroplasty; CTHA, cemented total hip arthroplasty.

after conversion ($p = 0.026$). From the 12th month after conversion to the final follow-up, CTHA yielded better functional outcomes than UTHA (all $p < 0.05$). Almost 76% of the patients who developed MoM-THA failure and underwent conversion to UTHA or CTHA had an acceptable HHS at the final follow-up. Differences in the HHS were not significant between the two groups 6 months after conversion.

Secondary endpoint

Fifty-four major orthopaedic complications occurred among the 106 patients in the UTHA group versus 27 complications among the 102 patients in the CTHA group. Of the 54 complications in the UTHA group, 12 (11.5%) involved periprosthetic fractures and 18 (17.3%) were associated with aseptic loosening. The re-revision rate was 14.4%. Of the 27 CTHA-related orthopaedic complications, 4 (3.9%) involved periprosthetic fractures and 7 (6.8%) were associated with aseptic loosening. The re-revision rate was 4.9% (Table 4). The between-group difference in the re-revision rate was significant at the last follow-up (14.4% for UTHA vs. 4.9% for CTHA, $p = 0.021$). The rate of re-revision attributed to aseptic loosening was 73.5% in the UTHA group and 66.5% in the CTHA group ($p = 0.014$).

Discussion

The current findings provide evidence that the revision of primary MoM-THA failure using CTHA results in superior mid-term clinical outcomes compared with the use of UTHA. To our knowledge, this is the largest study of the outcomes of conversion after MoM-THA failure.

Complications of MoM-THA related to ARMD can result in significant bone and soft tissue destruction as well as increased metal ion levels, especially cobalt and chromium, potentially increasing the risk of implant failure and posing a challenge for future revision.^{14,15} Metal ions can inhibit osteoblast gene expression, and they have a negative impact on osteoblast cell numbers and activity.^{15,16} This can ultimately result in bone ingrowth failure in the uncemented components utilised during conversion to UTHA after MoM-THA failure.¹⁶

MoM-THA revision is associated with high rates of orthopaedic complications due to periprosthetic fracture, aseptic loosening, and dislocation.² In the 2018 National Joint Registry Annual Report,⁴ the 14-year cumulative probability of revision was 22.2% for uncemented stemmed MoM-THA. Whether increases in hip stability exist following MoM-THA revision has become one of the key indicators.^{2,13} Hip stability following conversion to

CTHA is superior to that following conversion to UTHA because of the instability of the bone and uncemented components.¹⁷ Macroscopic damage or bone defects are often present at the time of UTHA re-revision.¹⁸ The cause of these bone defects is associated with malpositioning and a design that is too shallow for the acetabular component, resulting in atypically elevated wear triggered by edge loading.^{19,20} One study showed a high rate of aseptic loosening of the femoral component after UTHA re-revision due to MoM-THA failure.²¹ Failure due to aseptic loosening occurs more frequently with UTHA re-revision than with CTHA re-revision.^{2,7} The most appropriate re-revision intervention to decrease the high rate of aseptic loosening is a matter of ongoing debate.² Perhaps there is an effective solution when both the femoral and acetabular components are well ingrown.

Despite the continued advancements in prosthetic materials, the risks associated with conversion from MoM-THA to UTHA or CTHA remain a substantial concern.^{2,4} However, the obtainable literature²⁰ on the outcomes of this type of conversion is lacking and contradictory. A growing but still extremely limited body of literature describes the role of UTHA or CTHA revision in the setting of prior MoM-THA failure and has demonstrated significant differences in clinical outcomes, although all the studies are limited by small sample sizes and/or short-term follow-up periods.^{2,6} Undeniably, invasive revision procedures are associated with a high rate of orthopaedic complications.⁴ However, we failed to detect noteworthy distinctions regarding the rates of major orthopaedic complications 12 months after conversion. Concerns have been raised regarding whether these two types of conversion have substantial differences in mid-term outcomes, including orthopaedic complication rates.^{22,23} In 2009, Eswaramoorthy

et al.²⁴ described 76 patients who underwent conversion from MoM arthroplasty to UTHA. Similar to the findings observed in the current study of failed MoM-THA treatment, both aseptic loosening and periprosthetic fracture were the primary orthopaedic complications due to conversion. The authors also reported a high rate of major orthopaedic complications (24%), mainly attributable to a high rate of aseptic loosening (20%). Stryker et al.²⁵ reported on 114 cases of conversion from MoM-THA to CTHA and showed a major orthopaedic complication rate of 18% with a re-revision rate of 7%, primarily attributable to aseptic loosening (14%).

Femoral aseptic loosening, especially in young, active patients, was a common factor for re-revision after conversion in the current study. This has also been found by other authors who assessed UTHA or CTHA revisions. CTHA was developed in an effort to improve the fusion of cement and bone tissue and has become conventional for MoM-THA revision failure.^{2,5} Short-term or mid-term results of CTHA conversion following MoM-THA failure have revealed extremely low rates of major orthopaedic complications, especially aseptic loosening.^{8,9} Rahman et al.⁶ described 20 patients who developed MoM-THA failure and underwent conversion using CTHA; few patients were found to have aseptic loosening.

This current analysis also revealed that the reason for conversion has a prevailing impact on the outcome of conversion. With modern THA and surgical techniques, conversion due to an indication of MoM wear has low rates of re-revision, regardless of the use of UTHA or CTHA for conversion, whereas conversion due to conventional periprosthetic fracture tends to be associated with a higher rate of re-revision. It is imperative that these facts are understood by orthopaedists and patients prior to conversion.

This study has three main limitations. First, selection bias was unavoidable because of the exclusion of a number of patients. Second, this retrospective observational study was susceptible to errors in the recording of differences in comorbidities and orthopaedic complications, which may have created unaccounted confounding variables and may have resulted in a diminished power to draw convincing conclusions. Attempts were made to allow for more than a few confounding variables; nevertheless, we believe that this analysis is inadequate. Third, we failed to include data on metal ion concentrations and information about high- and low-volume orthopaedists. Despite these limitations, we believe that the margin of error is tolerable in the current setting because of the relatively large sample size.

In conclusion, the mid-term results reported in this study support a growing body of evidence that conversion to CTHA after primary MoM-THA failure is associated with more significant improvements in the modified HHS and lower major orthopaedic complication rates than conversion to UTHA.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ORCID iDs

Mingdong Zhao  <https://orcid.org/0000-0002-6960-9856>

Xinchao Zhang  <https://orcid.org/0000-0002-7618-6396>

References

1. Barrett WP, Kindsfater KA and Lesko JP. Large-diameter modular metal-on-metal total hip arthroplasty incidence of revision for adverse reaction to metallic debris. *J Arthroplasty* 2012; 27: 976–983.
2. Borton ZM, Mumith AS, Nicholls AJ, et al. The outcome of revision surgery for failed metal-on-metal total hip arthroplasty. *J Arthroplasty* 2019; 34: 1749–1754.
3. Koenig K, Huddleston JI, Huddleston H, et al. Advanced age and comorbidity increase the risk for adverse events after revision total hip arthroplasty. *J Arthroplasty* 2012; 27: 1402–1407.
4. Lainiala OS, Reito AP, Nieminen JJ, et al. Declining revision burden of metal-on-metal hip arthroplasties. *J Arthroplasty* 2019; 34: 2058–2064.e1.
5. Mata-Fink A, Philipson DJ, Keeney BJ, et al. Patient-reported outcomes after revision of metal-on-metal total bearings in total hip arthroplasty. *J Arthroplasty* 2017; 32: 1241–1244.
6. Rahman WA, Amenabar T, Hetaimish BM, et al. Outcome of revision total hip arthroplasty in management of failed metal-on-metal hip arthroplasty. *J Arthroplasty* 2016; 31: 2559–2563.
7. Hailer NP, Garellick G and Karrholm J. Uncemented and cemented primary total hip arthroplasty in the Swedish Hip Arthroplasty Register Evaluation of 170,413 operations. *Acta Orthop* 2010; 81: 34–41.
8. Chammout G, Muren O, Laurencikas E, et al. More complications with uncemented than cemented femoral stems in total hip replacement for displaced femoral neck fractures in the elderly. A single-blinded, randomized controlled trial with 69 patients. *Acta Orthop* 2017; 88: 145–151.
9. Makela KT, Eskelinen A, Paavolainen P, et al. Cementless total hip arthroplasty for primary osteoarthritis in patients aged 55 years and older. Results of the 8 most common cementless designs compared to cemented reference implants in the Finnish Arthroplasty Register. *Acta Orthop* 2010; 81: 42–52.

10. Smabrekke A, Espehaug B, Havelin LI, et al. Operating time and survival of primary total hip replacements - An analysis of 31745 primary cemented and uncemented total hip replacements from local hospitals reported to the Norwegian Arthroplasty Register 1987-2001. *Acta Orthop Scand* 2004; 75: 524-532.
11. Lazennec JY, Brusson A, Dominique F, et al. Offset and anteversion reconstruction after cemented and uncemented total hip arthroplasty: an evaluation with the low-dose EOS system comparing two- and three-dimensional imaging. *Int Orthop* 2015; 39: 1259-1267.
12. Crawford DA, Adams JB, Morris MJ, et al. Revision of failed metal-on-metal total hip arthroplasty: midterm outcomes of 203 consecutive cases. *J Arthroplasty* 2019; 34: 1755-1760.
13. Manrique J, Paskey T, Tarabichi M, et al. Total hip arthroplasty through the direct anterior approach using a bikini incision can be safely performed in obese patients. *J Arthroplasty* 2019; 34: 1723-1730.
14. Lee R, Essner A and Wang AG. Tribological considerations in primary and revision metal-on-metal arthroplasty. *J Bone Joint Surg Am* 2008; 90A: 118-124.
15. Matharu GS, Judge A, Murray DW, et al. Trabecular metal versus non-trabecular metal acetabular components and the risk of re-revision following revision total hip arthroplasty. *J Bone Joint Surg Am* 2018; 100: 1132-1140.
16. Pelt CE, Erickson J, Clarke I, et al. Histologic, serologic, and tribologic findings in failed metal-on-metal total hip arthroplasty. *J Bone Joint Surg Am* 2013; 95: e163.
17. Sternheim A, Abolghasemian M, Safir OA, et al. A long-term survivorship comparison between cemented and uncemented cups with shelf grafts in revision total hip arthroplasty after dysplasia. *J Arthroplasty* 2013; 28: 303-308.
18. Von Roth P, Abdel MP, Harmsen WS, et al. Uncemented jumbo cups for revision total hip arthroplasty. *J Bone Joint Surg Am* 2015; 97A: 284-287.
19. Hasegawa M, Sudo A and Uchida A. Alumina ceramic-on-ceramic total hip replacement with a layered acetabular component. *J Bone Joint Surg Br* 2006; 88B: 877-882.
20. Jameson SS, Baker PN, Mason J, et al. The design of the acetabular component and size of the femoral head influence the risk of revision following 34 721 single-brand cemented hip replacements. A retrospective cohort study of medium-term data from a national joint registry. *J Bone Joint Surg Br* 2012; 94B: 1611-1617.
21. Moojen DJF, Van Hellemond G, Vogely HC, et al. Incidence of low-grade infection in aseptic loosening of total hip arthroplasty. *Acta Orthop* 2010; 81: 667-673.
22. Danesh-Clough T, Bourne RB, Rorabeck CH, et al. The mid-term results of a dual offset uncemented stem for total hip arthroplasty. *J Arthroplasty* 2007; 22: 195-203.
23. De Witte PB, Brand R, Vermeer HGW, et al. Mid-term results of total hip arthroplasty with the CementLess Spotorno (CLS) System. *J Bone Joint Surg Am* 2011; 93A: 1249-1255.
24. Eswaramoorthy VK, Biant LC and Field RE. Clinical and radiological outcome of stemmed hip replacement after revision from metal-on-metal resurfacing. *J Bone Joint Surg Br* 2009; 91B: 1454-1458.
25. Stryker LS, Odum SM, Fehring TK, et al. Revisions of monoblock metal-on-metal THAs have high early complication rates. *Clin Orthop Relat Res* 2015; 473: 469-474.