Journal Club: 31 March 2010
Organiser: Mr Alister Hart and Professor JP Cobb
Chairman: Mr James Scott
NW Thames Rotation Journal Club

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Topic: Which Bearing Surface Is Best?

The advantaged of metal on metal (MoM) bearings over other surfaces such as highly cross linked polyethelyne and ceramic have attracted much debate in the world of hip arthroplasty. In particular concerns have been raised over the local and systemic effects of wear debris. The London Implant Retrieval Centre (LIRC), based at Imperial College (Charing Cross Hospital), is dedicated to investigating the causes of failure in MoM patients, and we therefore have a strong specialist interest in this bearing surface. The March journal club provided an ideal opportunity to examine three recent and one classic landmark paper investigating wear in differing bearings. Papers were chosen by the organisers and critiqued by four registrars who had experience of hip arthroplasty in their training. The papers were chosen for subject matter and impact, and were not exclusively from JBJS (Br). The critiques were presented to an audience of varying seniority, experience and background. In attendance were three consultants ready to critique the critiquers, 11 avid registrars, five highly motivated medical students, three quietly interested LIRC research scientists, four keen physiotherapists and the illustrious Editor of JBJS (Br).
The session was dedicated not only to bearing surfaces, but perhaps more importantly, to the evaluation and appraisal of evidence based literature. We were fortunate enough to hear Mr Scott give enlightening and valuable advice on critically analysing papers, as well as the standard which JBJS (Br) expect from submissions.
The registrars were then given ten minutes to present their reviews, followed by discussion on the quality of the each presenter's critique and the impact of the paper on clinical practice.
The afternoon proved to be a highly informative and educational session that gave much food for thought on the subject of 'which bearing surface is best'.
Examples of the critiques given are presented below:

Are ceramic on ceramic hips better?

Wear and acetabular component orientation in third generation alumina-on-alumina ceramic bearings: an analysis of 33 retrievals.
Lusty PJ, Watson A, Tuke MA, Walter WL, Walter WK, Zicat B
J Bone Joint Surg [Br] 2007;89-B:1158-64

Critique by Mr Kinner Davda

Overview

This paper was chosen for its impact on the understanding of wear in ceramic and ceramic bearings: at the time of publication this was the largest series of retrieved ceramic implants in a consecutive patient series.

This paper reportedly examined 33 retrieved CoC bearings for femoral and acetabular wear,and related this to the acetabular component orientation analysed on plain radiographics. The authors conclude that low acetabular anteversion (< 15°) is associated with significantly increased ceramic wear.

Review

This critique examines the paper section by section, highlighting the positive aspects of each, finishing with a critical appraisal and suggestion for improvements.

Introduction

The introduction is short and succinct, emphasising that although the wear characteristics of ceramic are established in 'ideal' laboratory settings, little is known of what occurs in the in vivo environment. The last paragraph clearly defines the aim of the paper, but fails to state the study design.

Method

The method reveals this is a retrospective analysis of a consecutive series of approximately 2800 patients who had undergone both primary CoC uncemented and revision total hip replacements, by 3 surgeons at one centre during an eight year period . Patient demographics, pre-operative diagnosis, as well as the number and types of implant used are clearly written.
The surgical approach used by the 3 surgeons is described, in particular that the authors assumed that the pelvis was flexed to 20° on the operating table, depending on the bracing method used. Furthermore that the acetabular component was placed at 45° anteversion. It was felt that this was a high anteversion value and may possibly have been a typing error where the authors had meant to write 'inclination'. Had this been the case however, we assumed this would have been corrected by the authors or journal in the revision writing process. We also ask how the authors could have standardised the placement of an acetabular cup using anatomical landmarks alone, when numerous studies have shown the variations in cup positions achieved by even expert surgeons.

A total of 41 CoC bearings were retrieved during the study period, however five bearings were excluded for having only been *in situ* for less than six months. This left 33 retrievals available for analysis: 33 femoral heads and 28 acetabular liners (as not all cups are explanted). The clinical situations leading to explantation are summarised. Ultimately 24 heads and 19 cups were available for wear analysis.
Wear measurements taken from explanted femoral heads correlate well with those from explanted heads (CC = 0.93) and therefore taken as a surrogate marker for cup wear. The validity of this method was questioned by our engineers currently involved in MoM wear analysis. Furthermore, the method described lacks the sufficient clarity for an engineer to reproduce the wear analysis from reading this paper.
The authors tell is only bearings with a wear stripe are used, but it is unclear what this exact number is and if it represents the original 24 head available for analysis.

Radiographs are measured by two of the authors for both inclination and version using purpose software validated previously using computed tomography (CT) . A Bland-Altman analysis of agreement would have been more appropriate than the correlation coefficient (0.86 for version) measured. The method of making this measurement on plain radiographs is not given. When we examined the original validation study cited by the authors, we found that only 11 CTs had been used, on a non standardised protocol with cup orientation measurements made on one axial slice. There may have been variablility in pelvic tilt rendering the measurement inaccurate. No reliability data is provided.
The use of parametric statistics and correlation coefficients is appropriate for the study; the significance level of the p value is stated to <0.05.
Results demonstrate the low wear rate of ceramic as a bearing with a median rate for heads at $0.01mm^3$/year and $0.04mm^3$/year for cups. The authors report no association for age (p=0.53), nor time *in situ* or bearing size. P values are not reported for the latter.
A correlation is demonstrated between high wear and anteversion less than 15°. No values for inclination are available, presumably as inclination measurements showed poor correlation between observers.
The discussion is well constructed and written, giving an excellent explanation of the possible mechanism of higher wear in low version cups. Anterior impingement is likely to lead to posterior head subluxation, leading to rim contact and edge loading and failure of fluid film lubrication. This ultimately leads to increased contact stresses and accelerated rates of wear.
In summary, the title is erroneous as only 24 heads and 19 cups were analysed, not 33 as suggested. The method of cup measurement from radiographs is of questionable accuracy. The results could have been better reported with ‘p’ and ‘r’ values. Topics in both methods and results are introduced with ‘wear’ and then ‘orientation’, an order which is reversed in the discussion.We would prefer to have consistency in the style of the paper in this regard.
In conclusion, this paper demonstrates the excellent wear properties of ceramic bearing surfaces and explains the likely mechanism of failure when related to cup version. It made a significant contribution to the literature on ceramics at the time of publication.

What was the problem with MOP hips? A Classic Paper

The mechanism of loosening of cemented acetabular components in total hip arthroplasty. Analysis of specimens retrieved at autopsy.
Schmalzried TP, Kwong LM, Jasty M, Sedlacek RC, Haire TC, O'Connor DO, Bragdon CR, Kabo JM, Malcolm AJ, Harris WH.
Clin Orthop 1992;274:60-78.

Critique by Mr Wael Dandachli PhD, Spr

Overview

This is an observational study which investigates the mechanism of loosening of cemented acetabular components by analysing acetabular specimens retrieved at autopsy using radiographic, biomechanical and histological methods as well as wear analysis. It concludes that the mechanism of loosening is biologic and related to high-density-polyethylene (HDP) wear particles.

Introduction

There is evidence for both mechanical and biological causes of acetabular component loosening. Data on the aetiology come from radiographic and histological analysis of failed prostheses, but the initial events in the process are unknown. In contrast to femoral stem loosening which is symptomatic and related to initial failure at the cement-metal interface, acetabular loosening remains clinically asymptomatic in the early stages and involves failure at the bone-cement interface. The aim of the study was therefore to elucidate the mechanism of failure of fixation of cemented acetabular components.

Materials and Methods

A total of 14 hemi-pelvices which were obtained at autopsy of 11 patients (3 had bilateral THA) were analysed. They came from eight women and six men, and consisted of 13 primary and one revision arthroplasty. They all had cemented non-metal-backed polyethylene acetabular components. The time from THA to death ranged from 58 to 210 months.
Clinically, 11 had satisfactory function, two had symptoms consistent with loosening, and function in one was unknown. There were no exclusions, but radiographic analysis was not possible on two specimens as the components were radiolucent. Radiological analysis consisted of five projections: AP, iliac and obturator obliques, and inlet and outlet views. It is unclear how the specimens were mounted. The criteria for loosening were one or more of the following: migration, cement fracture, and complete radiolucency of any width around the entire bone-cement interface on any projection. Wear analysis involved examination with optical microscopy, making casts of the interior surface of the polyethylene and calculating linear and volumetric wear. Mechanical motion testing used an axial loading force and torque. Finally histological examination was done using 4 mm coronal sections of the specimens coupled with radiographs and light and electron microscopy. The bone-cement interface was examined and the presence and distribution of any intervening soft tissue was noted.

Results

Radiological analysis showed that four components were loose and eight were stable. The oblique views added to the sensitivity, especially the obturator oblique. The demarcation was found to be circumferential and wider at the periphery (intra-articular surface). With regards to mechanical testing, three of the four radiographically loose components were found to be too loose for analysis. The stability of the remainder of the components ranged from well fixed to grossly loose. Motion occurred at the bone-cement interface, and no correlation was found with age, gender, months of service, or implant type or diameter. Wear analysis showed a direct relationship between volumetric wear and torque displacement, and specimens that had evidence of impingement had more significant loosening. Histologically, there was no evidence of loosening between the HDP and cement. There was variable soft tissue interposition between bone and cement in all specimens, thickest at the intra-articular margins, and the extent of soft tissue was directly related to implant stability. The loose specimens had a thick membrane containing macrophages, giant cells and HDP debris, and there was a transition zone from soft tissue interposition to intimate bone-cement contact. There was no evidence of mechanical failure.

Discussion

The relationship between radiolucency and acetabular component fixation has been investigated before. Hodgkinson et al found a definite correlation between a continuous radiolucent zone and loosening. Two theories for acetabular component loosening are hypothesised, mechanical and biologic. Both theories suggest formation of a soft tissue membrane in the bone-cement interface. Evidence against the mechanical theory includes absence of cement fragmentation and PMMA particles. The authors' findings are in agreement with Hodgkinson et al's. The authors stress that the histology of the transition zone is critical in support of a biologic mechanism. They hypothesise that as HDP particles go into synovial fluid they enter small defects in exposed bone-cement interface. This in turn stimulates a macrophage response and leads to the formation of the membrane. The authors then discuss the limitations of the study. They mention factors affecting stability and wear characteristics that were not evaluated in the study, including component factors (density of HDP, manufacturing technique, effects of exposure to load and to synovial fluid), bone quality, and initial degree of stability. Other limitations included a small sample size and factors that may contribute to loosening that were not investigated, including sepsis, malposition, dislocation, and impingement.

Comments

This study addressed a very topical issue at the time. It shed a light on the mechanism of late failure of cemented acetabular cups. The authors carried out a detailed and thorough analysis of the specimens, and their findings led to further developments in HDP to improve wear characteristics. On the negative side, there were some sampling weaknesses and the sample size was small. Several confounding variables that may affect loosening may have had a significant impact on the outcome, and the authors have acknowledged these.