Session 3: Controversies for Bearing Surfaces in THR

Learning Objectives
Upon completion of this activity, participants should be able to:

1. Understand the indications and known methods for the use of each of the alternative bearings over conventional polyethylene.

2. Describe the major disadvantages or potential risks with the use of the new alternative bearings when compared with conventional polyethylene.

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Highly Cross-linked Polyethylene in THA

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Background: Contemporary total hip arthroplasties with ceramic-on-ceramic, metal-on-metal, and those with highly cross-linked polyethylene all appear to have favorable midterm results in regard to wear. Each bearing surface has a distinct set of advantages and disadvantages and for that reason a consensus on the appropriate use of each is unlikely to emerge in the near future. Some surgeons will undoubtedly choose 1 bearing surface and be comfortable in applying that to all patients. Other surgeons will selectively use each of the bearing surfaces in an effort to balance the pluses and minuses to the clinical circumstance of individual patients.

Methods/Clinical results: In both basic science bench testing and early to mid-term clinical follow-up, each of the 3 bearing surfaces demonstrate a substantial reduction in wear as compared to traditional polyethylene. The reduction in wear that is seen with highly cross-linked polyethylene is not quite as dramatic as it is with the hard-on-hard ceramic or metal bearings. Highly cross-linked polyethylene does however present some distinct practical advantages over both ceramic and metal. Highly cross-linked poly is unlikely to experience the catastrophic problem of ceramic fracture nor does it cause the
marked elevation in serum metal ion levels caused by metal bearings. Impingement of the hip stem trunnion against a ceramic or metal articulation is cause for substantially more concern than if the impingement occurs against a cross-linked liner. Surgeons have a much wider array of intraoperative choices with cross-linked polyethylene liners in regard to head size (28, 32, 36, 40 etc), orientation (0, 10°, 20° elevation), and offset (standard, lateral offset). Finally, as cost pressures once again reemerge it should be recognized that cross-linked polyethylene is substantially less expensive than comparable ceramic or metal bearings.

**Conclusions/Clinical relevance:** For the majority of patients in my total hip practice their needs are met most appropriately with a highly cross-linked bearing surface. For very young, active female patients of child-bearing age, a ceramic-on-ceramic bearing has a role. For a subset of very active male patients, particularly those with posttraumatic arthritis, a metal-on-metal bearing is discussed.

References:

**Why I Use Ceramic-Ceramic**

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**Background:** Despite the great success of conventional ultra high-molecular-weight polyethylene as a bearing surface for THA, wear and resultant osteolysis became one of the leading causes of failure and reoperation. Three alternative bearings to conventional polyethylene have become popular in the past decade: metal-on-metal, metal or ceramic-on-highly cross-linked polyethylene, and alumina ceramic-on-alumina ceramic. Alumina ceramic bearings are attractive because of their extreme hardness and scratch resistance, their hydrophilic nature with improved lubrication, the absence of metal ion release, far less volumetric wear debris, and their superior wear resistance compared to all other available bearing surfaces.

**Methods & materials:** In October 1996 a prospective, controlled, randomized, multicenter trial was started comparing ceramic-on-ceramic to metal-on-conventional polyethylene.
Five surgeons at 5 independent sites have followed 475 patients divided between 3 cohorts who received ceramic-on-ceramic and 1 cohort who received the control metal-on-polyethylene. There was no difference in demographics for the 4 study groups, and the average age of the patients in the 4 study groups ranged from 52 to 55 years at the time of implantation.

**Clinical results:** Survivorship, revision for any reason, for the ceramic implants (96.5%), was significantly higher ($P = .012$) than for the control metal-on-polyethylene (91.3%). One percent of the ceramic patients report occasional squeaking, none of which are of any major significance or have resulted in revision. The only bearing surface–related failures for the ceramic patients (0.5%) occurred for a liner fracture at 6 years and an anterior chip fracture recognized at 9 years. Bearing surface–related failures for the polyethylene control occurred for osteolysis (2.1%). Osteolysis for the metal-on-polyethylene control group was seen in 31% and for the ceramic-on-ceramic in 1% ($P = < .001$).

**Conclusions & clinical relevance:** Increased volumetric wear debris generated at the bearing surface in total hip arthroplasty can lead to osteolysis and a need for reoperation. Ceramic-on-ceramic bearings have superior wear resistance compared to all other available alternative bearing surfaces and provide an excellent alternative for young, active, and high-energy athletic individuals.

References:

Metal-on-Metal Articulations With Large Diameter Heads

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With the introduction of alternative bearings in the past several years, surgeons have moved from the traditional utilization of 22, 26, 28, and 32-mm heads to larger head diameters in total hip arthroplasty (THA). The reported benefits of large femoral heads are the enhanced stability secondary to the increased range of motion prior to impingement and the increased jump distance required for subluxation of the head from the acetabulum. Numerous studies have documented significant reduction in wear with highly cross-linked polyethylene, even when large femoral heads are used. The Achilles heel of highly cross-linked polyethylene, namely diminution and its mechanical properties, has been reconciled with second-generation highly cross-linked polyethylene. Large-head ceramic components are favored, not only secondary to the afforded enhanced stability, but also because of the increased fracture resistance. To date, there have been no reported incidences of fracture of femoral heads of size 36 mm or larger. However, it is only with metal-on-metal articulations that femoral heads can be offered in sizes that closely replicate normal anatomy.

Following our initial experience with 28- and 32-mm metal-on-metal articulations, we performed a series of THA with 38-mm metal-on-metal articulations. We have reported our success with respect to enhanced stability with this particular device. In November 2004, a system of large modular head, monoblock shell metal-on-metal acetabular components was introduced. In this system, head sizes range from 38 mm to 60 mm, with acetabular components being 6 mm larger than the femoral head and therefore ranging from 44 mm to 66 mm. As of October 2008, we have performed 886 primary THAs in 786 patients with this device. In this series the average diameter of the implanted femoral head was 56 mm (range: 46-66 mm; SD 3.9). In 89 randomly selected THA, the resected femoral head was measured intraoperatively with a caliper by an independent observer. The surgeon was not apprised of the measurement and proceeded to complete the arthroplasty according to standard protocol. In 274 THAs, radiographic measurements of the contralateral native femoral head were made using a calibrated PACS system. In cases measured intraoperatively, the femoral head size was restored to within 6 mm of the resected femoral head, with an average restoration of 0.7 mm increase. In cases measured with the calibrated PACS system, the implanted femoral head was found to be on average 2.4 mm larger than the contralateral femoral head.

To date, there have been no dislocations in this series. Nine cups have been revised: 2 because of sepsis, 4 because of aseptic loosening, 1 because of failure of ingrowth, 1 because of metal hypersensitivity, and 1 because of metallosis.

Metal Hypersensitivity Testing in Total Joint Arthroplasty Patients: Studies report that lymphocytic reactivity to metal may predict poor implant performance or failure in THA
and total knee arthroplasty (TKA). Reports also note an increased incidence of perivascular lymphocytic infiltration (PVLI) in the soft tissues surrounding failed implants in patients with metal hypersensitivity. These findings are of concern with metal-on-metal total hip arthroplasty.

Serum from 22 patients with a painful joint or failed total joint arthroplasty, including 13 patients with metal-on-metal THA articulations, 1 metal-on-polyethylene THA, 1 ceramic-on-polyethylene THA, 5 patients with a painful metal-on-polyethylene TKA, 1 with metal-on-polyethylene unicompartmental knee arthroplasty, and 1 preoperative TKA patient, were sent for immune response testing at a national laboratory with previously validated and published methodology. Capsular tissue from 140 revision THA and 137 revision TKA was sent to pathology to rule out perivascular lymphocytic infiltration (PVLI).

Serum from 16 of 22 (73%) patients was reactive to 1 or more metals. Ten of 15 patients with painful or failed hips (67%) and 6 of 7 (86%) with painful or failed knees tested positive, which was not statistically different. Eight of 13 (62%) patients with metal-on-metal THA articulations had positive reactions, which was not different statistically in comparison with the patients with metal-on-polyethylene and ceramic-on-polyethylene articulations, both of whom had positive reactions. In the overall cohort, reactivity was to 1 metal in 6 cases, 2 metals in 4, 3 metals in 1, 4 metals in 1, 5 metals in 2, 7 metals in 1, and 8 metals in 1. The most common reaction was to nickel, present in 13 cases (59%). Other reactions noted were to iron in 6, zirconium in 6, cobalt in 5, chromium in 5, molybdenum in 5, vanadium in 3, and aluminum in 3. The preoperative TKA patient tested demonstrated high reactivity to nickel, and mild to zirconium. Surgical pathology results revealed a significantly higher number of failed TKA (65 of 137; 47%) with evidence of PVLI compared with failed THA (46 of 140; 33%; \( P = .0132 \) Pearson’s chi-square).

These findings question the utility of serum metal sensitivity testing in the diagnosis and management of possible metal hypersensitivity with a similar prevalence of positive results as that previously published for osteoarthritic controls. Additionally, findings of PVLI do not appear to hallmark metal hypersensitivity associated with metal-on-metal THA, as the prevalence is higher with failed TKA than failed THA. New testing modalities require development to assist in the evaluation of painful metal-on-metal THA.

References:
Modern THA-bearing surfaces include metal on metal (MOM), ceramic, and highly cross-linked polyethylene (XL). The harder the bearing surface, the greater the wear resistance and therefore MOM and ceramic-on-ceramic bearings have the potential for better wear resistance than polyethylene.

XL polyethylene studies with greater than 4 years of follow-up have demonstrated reduced proximal head penetration and wear rates. At 2-5 years, studies have shown a 42%-72% reduction in wear rates for annealed, cross-linked polyethylene. Earlier generations of XL polyethylene suffered from reduced toughness, fatigue, and tensile strength. Liner fractures appear related to high acetabular abduction angles combined with thin polyethylene.

A study of alumina ceramic heads on ceramic acetabular components demonstrated a 20-year survival of 85% for cemented and 61.2% for cementless cups. A recent alumina-on-alumina cementless design followed for an average of 62 months showed 99.7% of cups were stable, 1.4% developed osteolysis, and there were no fractures. Wear in ceramic designs has been related to positioning of the cup in < 15° of anteversion. Of concern has been the advent of squeaking associated with positions of excessive anteversion and abduction opening. Retrievals studies have shown have rim chip fractures and cracks in the acetabular liners, particularly when the components are malpositioned. A head fracture rate of 1.4% was recently reported with all cases occurring with short femoral necks.

MOM designs allow for low wear rates and the use of large heads, which improve stability and range of motion. The 20-year survivorship of the McKee-Farrar design was 84% and 74% at 28 years, with minimal osteolysis. Concerns with MOM include elevated serum ion concentrations, metal allergy, pseudotumors, osteolysis, and runaway wear related to malpositioned acetabular components.

In summary, all 3 bearing surfaces have demonstrated substantial wear improvements over traditional polyethylene, but with potential complications when sockets are malpositioned. Clinical decision making must take into account not only patient activity level, but tolerance for potential ion elevations, squeaking, and the need for features such as elevated rims or large heads.

References:
1. Digas G, Kärrholm J, Thanner J, et al. The Otto Aufranc Award: Highly cross-linked polyethylene in total hip arthroplasty: randomized evaluation of


**Case Presentations/Q&A**

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