What is the Best Bearing Type? 1/11/2011

A comparison of modern bearing types.

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As a patient there are four reasons you should consider a metal-on-metal bearing total hip replacement or resurfacing:

1. WEAR: Low.

2. BREAKAGE: Unbreakable bearing.

3. STABILITY: Maximum stability of the joint. Using a metal-on-metal bearing surface allows the manufacture of a large bearing hip joint that will not dislocate.

4. BONE PRESERVATION: Resurfacing is only possible with this bearing type. This allows bone preservation and avoidance of a stem in the femoral canal.

Hip replacement has come a long way since the 1950's. It has improved to the point where middle aged or older patients can expect a relatively long life out of the implants if they follow certain restrictions and don't participate in high impact sports. However, most implants are not good enough to allow full unrestricted activity at high demand levels. To move to this next level requires an implant that satisfies all three of the above-mentioned requirements. Only metal-metal bearings have this potential. We will address all three issues in detail separately:

1.WEAR:

Failure due to the adverse effects of wear has been identified as one of the primary problems with traditional metal-plastic bearings. They are not durable enough for many of today's younger more active patients. Traditional metal-on-plastic bearing devices have been shown to fail at a rate of thirty (30%) percent by seven years in this patient group. Mostly these failures have been due to reactions to wear debris. Recently, several new bearing couples have been developed that are more resistant to wear:

1. Cross linked Polyethylene: More durable than the standard plastic, socket liner but still not well tested. Previous modifications in plastics have been unsuccessful. Although wear performance is improved, the trade-off is that they are more brittle. The femoral head can be cobalt chrome or ceramic.

2. Ceramic-On-Ceramic : Very durable bearing surfaces. Unlikely to ever wear out. However, manufacture of this brittle material is very tricky, occasionally resulting in failure by fracture of the ceramic parts while in use.

3. Metal-On-Metal: Very durable bearing surface. Unlikely to ever wear out. No possibility of cracking like the ceramic.

Wear rates (as tested on simulator devices in the laboratory) of all three of these modern bearings are extremely low. Theoretically, they should all be able to last hundreds of years. The problem is that other factors enter the equation when implants are placed into the body. Corrosion and oxidation can now affect the implant. Position of the implant in the bone is critically important. Our understanding of this is improving, but there is still much to learn. Also wear patterns resulting from various activities vary significantly. This is not well reproduced in the laboratory. For all these reasons, wear rates predicted in the laboratory are always better than what can be achieved in real life. Despite these limitations, testing implants in the lab has allowed us to develop these new and much improved bearing types.

All of these new bearing types have been in use for 8-10 years. Implants made with these bearings all have approximately an 8-year survivorship of about 95%. This means that in 100 people implanted, 95 of them still have functioning implants after 8 years. Five out of a hundred have required revision surgery in those 8 years. No one can say for sure how long an individual implant in an individual patient will last. No data exists on how long these implants will last in people. Advertisements that declare that a company has a 20-year implant are false. Companies that take this approach are simply extrapolating from lab data and presenting unrealistic expectations. No data exists beyond 10 years. On the other hand, all of these modern bearings have already vastly outperformed the traditional metal-plastic bearing in high demand younger patients by 8 years. All of these implants are being constantly modified in hopes of further improving their success. However, it takes years to know if a modification has been an improvement or a step backward.

A case in point is illustrated by the recent (2010) recall of the DePuy ASR large bearing metal system. The profile of the cup was made shallower in hopes of improving the range of motion achievable when implanted. Also the radius mismatch (the gap between the head and the cup) was reduced because lab data indicated that this would decrease the wear rate. Unfortunately, the wear rate went up dramatically in many patients leading to an adverse wear reaction (tissue inflammation due to the wear debris). We have discovered that the shallower cup is harder to implant in an ideal angle to avoid a pattern of edge wear that has only been recently discovered. Also, these thin walled cups may slightly deform when they are implanted. If the manufactured gap is too small, it may disappear completely while the cup is hammered in and then equatorial bearing (the implants touch on the equator instead of at the apical pole as they should) may result. Both of these processes can dramatically accelerate wear and thereby result in overloading the tissue around the hip with wear debris. No one could have predicted this outcome in advance.

All artificial bearing surfaces shed wear debris when in use. The natural body fluid lubricates these artificial joints. If an abnormally high wear rate is present in an individual patient, problems may eventually occur because of this. The problems that develop are slightly different depending on the bearing surface chosen. I will briefly review all of them.

Plastic wear debris: This material never leaves the body. Plastic (polyethelene) is an alien product to the body. It builds up in the local tissues. Cells eat the material and then rupture releasing their enzymes into surrounding tissue. This results in gradual thickening of the surrounding soft tissue and in holes being chewed into the surrounding bone (osteolysis). Some of this debris is carried off to local lymph nodes and even the liver. But it never leaves the body. Other than the local damage that it causes, it does not seem to be otherwise toxic to the body. There is no way to measure the level of this material in blood tests. Newer cross-linked polyethelene is more resistant to wear and therefore releases much less of this material into the tissues. Therefore we are now seeing very little bone destruction with these implants at 8 years after implantation.

Metal wear debris: The primary metals are cobalt and chromium (trace amounts of molybdenum and nickel are also present). Both naturally occur in our biochemical systems. Chromium is even present in many vitamin supplement formulas. However, much higher quantities of these metals are deposited in the tissues around implants with metal bearings than a person would normally ingest in their diet. The metals are absorbed by local tissues, are washed out in the bloodstream and eliminated from the body through the kidneys. Blood levels can be measured. Abnormally high levels may be an indicator that the wear rate of the implant is too high. This science is still developing and we are not yet absolutely certain what blood level is a problem. I recommend monitoring blood levels after 2 years from surgery. If an abnormally high wear rate is present in a patient's implant, an adverse wear reaction may occur. This is usually seen as local fluid collection and soft tissue inflammation; bone destruction (osteolysis) is rare. The Oxford Group has called this reaction "pseudotumor". Their group of 20+ surgeons performing resurfacing has recently published numerous articles on their group of 1400 resurfacings with an alarming rate of pseudotumor of 5% at an average follow-up of 3 years. Their group is clearly an outlier among surgeons. Many other high-volume resurfacing surgeons have only rare cases of adverse wear. In my experience of over 3000 metal bearings (including 2300 resurfacing and 700 stemmed total hips) in 15 years, I have only encountered 3 cases of adverse wear to metal bearings. Also, in contrast to the Oxford experience, I have found revision of these to be straightforward. Although adverse wear reactions do rarely occur with metal bearings, past speculation of the metal causing cancer, kidney failure, or birth defects has not been substantiated by any scientific evidence.

There also exists much speculation about allergic reaction to these metals. However no clinically validated tests have yet been developed to measure this. Skin tests to metals are not predictive of problems with implanted metals. Blood based lymphocyte reaction tests have been studied extensively for years but they have also not proven to be predictive of problems. Furthermore these metals are also present in smaller amounts in metal plastic hip systems (because of the cobalt chrome femoral head) and virtually all knee replacements ever implanted. If allergy were a problem, it would surely be a problem with these implants systems as well.

Based on the phenomenal performance of these metal bearings in lab wear studies, we were caught by surprise by the reports of adverse wear in some patients in recent years. Fortunately, we can evaluate the wear rate with blood tests and evaluate soft tissue inflammation with newer MRI methods that can be used around implants. More importantly, we are learning more about acetabular component placement that will likely prevent these problems. With intra-operative XR control techniques that I have developed, I can now virtually guarantee that an acetabular implant is never placed with an inclination angle above 55 degrees, where a higher risk of wear problems is known to result.

Ceramic wear debris: Ceramic versions of zirconium and aluminum metals can be used to fashion very hard low wear bearings. The ceramic particles deposited in the tissues do not seem to cause either a soft tissue or bone destruction (osteolysis) process. However, if an abnormal wear pattern develops (stripe wear), loud squeaking may result. This can be so loud that the affected patient can literally be heard walking across the room. Some studies have reported this complication in 5% of patients, however most centers that use these bearings see this in less than 1-2% of cases. Revision surgery is required if this problem develops.

2. BREAKAGE:

Breakage of metal stems was fairly common in the past when they were made of stainless steel. Current acetabular shells and femoral stems are made of titanium or cobalt chrome. They are very resistant to breakage. However, in young high demand patients who run on them for many years, fatigue failure of the neck of the femoral prosthesis may eventually become a problem. Removal of the well-fixed bone-ingrown stem from the femur may then result in considerable bone destruction. Therefore anyone with a stemmed total hip should not engage in extensive running regardless of his or her implant bearing type.

Bearing fracture with a metal on metal cobalt chrome bearing has never been reported. Plastic or ceramic bearings, however, are subject to this problem.

The improved plastics (XLPE) have better wear characteristics, but have become more brittle as a result of the cross-linking process. They are therefore more prone to breakage. Because the wear rate is lower, these implants are increasingly made thinner and thinner to allow the femoral head size to increase. This is being done because it is well known that larger bearing size leads to greater hip stability (less dislocations). It is easy to see what the trade-off is. A patient with a thinner plastic liner in their hip is going to have a lower chance of hip dislocation, but a higher chance of liner breakage if he runs on it. Therefore impact activities should be avoided with these bearing types. All of this has been relatively untested in patients. Although results with 28mm cross-linked plastic bearings are available out to 8 years, larger sizes have only very short-term follow-up so far. Adding vitamin E to the cross-linked plastic (VEXLPE) does seem to prevent them from becoming as brittle; VEXLPE is no more brittle than standard plastic. So far only one company offers this product (BIOMET).

Ceramic bearings are very tough. But these materials are brittle. Fracture rarely occurs, but broken ceramic is impossible to remove completely from the tissues and can be a very damaging foreign body to any future bearing surface implanted at the time of revision for a broken ceramic piece. As these ceramic bearings are made thinner to improve hip stability, fracture seems more likely. Again there is a tradeoff between stability and risk of breakage. Fortunately newer zirconia / alumina mixed ceramic seems to be much stronger than previous types and more resistant to breakage. But thinner liners with this ceramic has only short clinical follow-up. Again impact activities should be avoided.

3. INSTABILITY:

Hip instability is the ***most common*** cause of failure leading to revision surgery in hip replacements in this country. Most hip dislocations begin within the first year after surgery, but sometimes they don’t start for years after the surgery. Overall the risk is 4% in the first 3 months, and about 7% by 10 years. About half of these become recurrent and require revision surgery. Therefore the revision rate quoted for dislocation always underestimates the problem by about half.

Many factors affect hip stability, but by far the most important is bearing size. It is often said that the larger the bearing size is, the lower the chance of dislocation. This is not completely true. Every person has a different hip bearing size. The goal is to reproduce a patient’s own hip bearing size with an implant. There is no advantage to removing more bone to implant a larger bearing than the natural one. Hips are naturally very stable joints. If we reproduce the natural biomechanical situation, dislocation is rare. To dislocate a natural hip requires tremendous force, such as is generated by falling out of a 2-storey window or ramming the knee into the dashboard of a car at 30mph. After the restraining hip ligaments are cut in order to replace a hip joint, much less force is required to dislocate the hip. If the natural hip biomechanics are reproduced with an anatomic sized artificial bearing, normal stability returns to the hip after the ligaments have healed in 6-12 months. If smaller bearing sizes are used, stability also improves with healing, but normal stability never returns. Permanent restrictions in how far the leg can be bent are therefore required. In most patients the hip feels normal and no problem develops. But those patients that experience dislocations can be very distressed by this. When the hip comes out, you can’t walk. You must be taken to the ER, given a powerful sedative and have your hip pulled back in place. The pain immediately goes away and you can walk again. Often you must wear a protective brace for 6 weeks and must be even more careful about following hip precautions after this time. In about half of the cases the hip stabilizes and nothing further needs to be done. In the other half of cases, repeated dislocations occur and revision surgery is required to solve the problem.

The standard bearing size for plastic and ceramic bearings has been 28mm for many years. As these materials have improved, the bearing sizes have increased. When we get to a 36mm size, the dislocation rate drops to 1%. Full sized anatomic bearings are only possible with metal-metal articulations (typically 48-52mm). Both hip resurfacing and stemmed total hip replacement can be performed using these anatomic sized bearings. When these are employed, the dislocation rate is less than ½% and full unrestricted range of motion activities can be allowed after 6-12 months (when the ligaments have healed).

Other factors that affect hip stability after hip replacement are: surgical approach chosen, position that the implant is placed, pre-existing neuromuscular disease (e.g. Parkinson’s disease), patients with loose ligaments (dysplasia, Ehlers-Danlos syndrome), failure of the hip ligaments to heal properly, damage to the hip musculature (abductor muscles).

BONE PRESERVATION:

Bone preservation is more important the younger the patient is. Hip resurfacing preserves most of the femoral head and neck. This bone is amputated if a stemmed total hip is employed. Hip resurfacing is only possible with metal-metal bearings made of precision manufactured cobalt-chrome. In the 1950's this was attempted, but the manufacturing techniques were not precise enough to make this successful. Metal-plastic bearings came to dominate the market in stemmed total hip replacement because precision manufacturing was not required when one side of the bearing was soft (plastic) and deformable. Resurfacing was abandoned. In the 1970's resurfacing was again attempted, this time with metal-plastic bearings. We quickly learned that thin plastic shells with large bearing sizes rapidly failed due to accelerated wear. Initially surgeons thought the failures were primarily due to osteonecrosis (ON) of the femoral head. Now we know that these failures were primarily due to plastic particle induced bone destruction (osteolysis). Resurfacing was again abandoned. In the 1990's we discovered the features that make metal –metal bearings work. Precision manufacturing techniques advanced to the point where these features could be routinely built into Implants. Derek McMinn pioneered a third attempt at hip resurfacing using modern precision manufactured cobalt chrome metal-metal bearings.

The key advantages of preserving the top of the femur with the hip resurfacing technique:

1. **Simplifies Revision**: If revision of the femoral component is required, this is substantially easier and lower risk for a resurfacing than a stemmed total hip. Typically if a resurfacing is revised, the femoral neck is divided, and placement of a revision femoral stem is no more difficult than a primary (first time) hip replacement stem. On the other hand, if a stemmed total hip is revised, the stem must first be removed from the femur. Significant bone loss may occur, requiring a longer stem and bone grafts to reconstruct this. Socket revision is no different for hip resurfacing or stemmed total hips. Bone preservation, is more important for younger people who are more likely to outlive their first implant. Older patients may be better off with a large bearing stemmed total hip replacement.
2. **Minimizes stress shielding**: Force is transferred through an implant to the bone it is attached to. If a stem bypasses bone, the force bypasses the bone as well. Bone that is not loaded is gradually lost. This is called stress shielding. Resurfacing implants load the femoral bone at the very top and therefore bone loss due to stress shielding is minimized.
3. **Avoids Thigh Pain:** If the femoral head is removed and a stemmed total hip is placed, some patients feel the stem. Bone ingrowth type femoral stems are stiffer than the surrounding bone. Force is applied to the stem and it is transferred to the bone. The surrounding bone is more flexible than the metal stem. This is called modulus mismatch. Some people can feel this difference as pain and have pain in the thigh with activity. 1-3% of patients report this despite the fact that they have a well-ingrown femoral stem. There is no known solution to this problem. There is evidence to suggest that patients with stemmed total hips are not able to regain high levels of impact sport activity as well as resurfacing patients are. I suspect that this is because they may have subtle thigh pain that limits them.
4. **Avoids stem breakage**: As discussed above, breakage of a modern femoral stem is rare. But extremely highly active young patients may eventually do this. Removal of a well fixed broken stem in stress shielded proximal femoral bone may lead to extensive bone loss that is difficult to reconstruct.
5. **Decreases wear**: If a stemmed hip is implanted, the femoral head component is mated to the stem by a morse-cone taper junction. Additional wear particles are generated at this junction. Studies have shown higher metal ion levels in the blood in stemmed large bearing hip replacements than in resurfacing with the same exact bearing type.

SUMMARY:

My opinion is that the advantages of metal on metal bearings strongly outweigh the potential risks in virtually all patients. There are only rare situations when I recommend another bearing type. In older patients (above 65 years) I generally recommend a stemmed large bearing metal-metal hip replacement. In younger patients I strongly advocate hip resurfacing.

There are other reasons that may affect a surgeons' decision-making process:

- Hip resurfacing is more difficult to perform than stemmed total hip replacement. Some surgeons are technically not capable of performing this operation. Even skilled hip surgeons have to go through a learning curve to develop this new skill. Even then the time per case is longer, usually for the same payment from the insurance company.
- Surgeons who do not perform hip resurfacing often don't even mention it as an option for younger patients who might benefit from this procedure. I believe all patients deserve to know their options and participate in the decision making process.
- Costs of ceramic and metal bearing implants are generally higher than plastic bearings. This does not directly affect the surgeon. The cost is borne by the hospital. The insurance company pays hospitals. Medicare and some insurance companies claim that they pay for services, but they reimburse at such a low levels that hospitals lose

money if expensive implants are used. Surgeons do wish to keep their hospitals solvent. Rarely they receive payments to help hospitals achieve cost savings. Sometimes hospitals simply limit a surgeons implant choices to save money. Sometimes insurance companies place limitations on implants allowed. I believe that hospital administrators and insurance company officials do not have the necessary knowledge base to make these decisions. These facts are rarely disclosed. My hospital does not limit my implant choice and I receive no payments from the hospital.

- Recent reports of adverse wear failures with metal bearings from the Oxford Group scare surgeons who have not used many of these bearings. They may think the bearings are primarily at fault. Surgeons who have used large numbers of these bearings for a long time like myself (over 3000 in 15 years), and have a low failure rate due to wear problems (3/3000= 0.3%), realize that failure due to wear is much lower than other failure modes and can be minimized with good technique.
- Some surgeons work with companies to develop implants and naturally get paid for this. I was the primary developing surgeon for the BIOMET recap and Magnum hip systems.

  Conflict of interest is an unavoidable part of the complex world we live in. Managing these conflicts in an honest fashion is our responsibility. Transparency is crucial.

There are no good head to head studies of these different implant types. The general survivorship of all modern bearing hip implants is about 95% at 8 years in younger higher demand patients. Therefore, there is much room for surgeons to disagree about what implant type is best. Surgeons have different skill sets; different implants may work better in the hands of different surgeons. Many patients today have more access to information and wish to take an active part in the decision making process. Time constraints make it impossible to explain all of these facts to patients in detail; therefore I have compiled this report.

This report is written from my biased point of view and barely scratches the surface on this complex subject. I hope it has been understandable and informative to you.

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