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A NEW APPROACH TO BEARING SURFACES FOR TOTAL HIP ARTHROPLASTY

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The most common cause of proximal femoral bone loss is due to osteolysis. Although the specific cause of lysis is not known, it has been attributed to a variety of factors, including motion of the implant and foreign body reaction to particulate debris, in particular to polymeric debris. It has been almost two decades since Willett first described the problem of polyethylene wear leading to peri-prosthetic inflammation, granuloma, bone resorption, and implant loosening. Since then, many studies have documented the finding of particulate bone cement and polyethylene in peri-prosthetic tissues.

In normal wearing artificial joints, linear wear rates of 0.05-0.2 mm per year results in the generation of about 25-100 min (25 to 100 mg) of polyethylene debris annually. On a basis of known dimensions of polyethylene particles found in tissues around hip prostheses, this equated to the annual production of tens to hundreds of billions of particles.

Variations of polyethylene wear rates probably relate to acetabular implant design, femoral head size, femoral head material, and at least in part to the quality of the polyethylene used. Wide variations are known to exist between batches of polyethylene and between different polyethylene suppliers.

Based on favorable clinical trials in Europe during the past decade, improved ceramic on ceramic and metal on metal bearing combinations have been renewed as possible solutions to the problem of polyethylene wear. This paper will review one such concept of ceramic on ceramic articular for use in total hip arthroplasty.

Ideally, the bearing surfaces for most sliding, rotating, or articulating bearing surfaces systems will be made from material having relatively high strength, high wear, and corrosion resistance, a high resistance to creep, and low frictional moments. However, in reality no one material presently exhibits all of these characteristics. Therefore, with present bearing systems compromises are typically made between these various characteristics.

Ceramics have characteristics which are very desirable for use in sliding, rotating, and articulating bearing systems. In addition to high compressive strength, they exhibit high wear and corrosion resistance with relatively low frictional moments. However, use of such ceramic materials in bearing Systems has been inhibited because such materials are susceptible to fracture due to their relatively low tensile and shear strengths. Thio weakness of ceramic materials is one reason why metal and/or polymeric materials have been used for many bearing surfaces. Compared to bearing ceramics, bearing metals and polymers typically have lower wear and corrosion resistance or resistance to creep and higher frictional moments.

In bearing systems where ceramics have been used, their low tensile and shear strengths often force the adoption of costly design compromises. Thus, one design compromise has been to make the entire bearing component rather than just a portion thereof out of solid ceramic, thereby increasing the amount of ceramic used and, therefore, effectively increasing the structural strength of the bearing surface. Such a solid ceramic bearing component can be larger and bulkier than its metal and/or polymeric counterpart.

Making an entire bearing component, like the acetabular cup, out of solid ceramic helps to compensate for the relatively poor tensile in shear strength typically found with ceramics. Also, because bearing ceramics are typically inflexible, additional manufacturing quality control of the geometry of both articular surfaces must be maintained in order to maximize the contact area between the two surfaces. If tight control is not maintained, point contacts may develop between the bearing surfaces. As the contact area between two bearing surfaces decreases, the stress that is transmitted between the surfaces increases. This can result in greater wear and increased possibility of fracture of one or both surfaces.

In the past one solution with this problem has been to manufacture prostheses with matching pairs of heads and cups. However, this solution is not only costly due to maintaining the quality levels required, but are additional inventory costs while making surgical intervention more difficult.

In an attempt to address these real life problems, a segmented ceramic bearing system has been developed. This segmented bearing system provides ceramic surfaces for mechanical bearings that would apply loads over a greater bearing surface area, resulting in reduced bearing stresses and, in turn, reduces creep, wear, and likelihood of fracture of the bearing surfaces.

The acetabular component is designed with several ceramic articular segments that are backed and held in a pre-determined pattern and configuration by either Polyetheretherketone or Polyethylene. Both of these materials have a lower elastic modulus than the segmented ceramic material. In addition, the polymeric material is reduced in height so that only the segmented ceramic material articulates with a ceramic femoral head.

Because of its resilience and lower elastic modulus, the polymeric material flexes as loads are transmitted between bearing surfaces while the shape of the surfaces of the segments remain relatively unchanged. This freedom of movement of the segments, under an applied load, allows for greater contact areas between bearing surfaces because the segments as a group are able to conform to the geometry of the opposing bearing surface. Thus, rather than having highly localized stress concentrations typically occurring in bearing systems any applied load is shared by a number of segments which result in lower stress being applied to the bearing surfaces and each segment.

An additional feature of this design is the formation of channels generated by locating the polymeric material slightly below the surface of the ceramic segments for lubrication and for allowing debris that finds its way into the bearing to either pass between the segments or be trapped in the polymeric material.

This design allows for the segmented composite insert to be used with hemispherical design cemented or cementless acetabular components. This highly innovative design provides for an alternative bearing surface that is cost effective while it reduces or eliminates the generation of articular polymeric or metallic debris which should have a tremendous positive effect on overall reduction of particulate debris resulting in increased longevity of our total hip reconstruction. A review of fatigue and wear data will be presented; however, to date no in vivo testing has been done and only long-term clinical data will prove the viability of this design approach.