Define tribology and discuss its effect on total hip arthroplasty (THA).

Tribology is defined as the science of interacting surfaces in relative motion and includes the principles of friction, lubrication, and wear of implant materials. Tribology of the articulating materials in THA is the most important issue for long-term survival of the implants because the fixation of implants either with or without cement has reached excellent long-term survival rates up to 20 years. Because the long-term success of an implant is based on permanent fixation and wear of the articulation, concerns about wear and osteolysis have highlighted the importance of tribology in THA.

What causes wear and corrosion of THA implants?

Wear particles produced from friction of the articulating materials have led to many failures. Wear particles of conventional polyethylene are produced when the polyethylene articulates with the metal head of the hip joint. These particles lead to osteolysis of the adjacent bone and subsequent loosening of the implant. Metal particles are caused by failure of metal-on-metal articulations, especially when using large-diameter heads. Another concern that has gained attention recently is corrosion at the interface of the metal head and femoral neck of the hip stem. This corrosion material is responsible for implant failure.

What role does imaging play in determining wear and corrosion of THA implants?

For effective clinical treatment of failures due to wear and corrosion, it is important to routinely evaluate a procedure’s clinical result. If patients report pain at the hip joint, perform radiography to search for possible osteolytic zones around the joint. However, some patients report no symptoms, so it is important to perform radiography routinely for at least 10 years after after implantation, especially in patients with metal-on-metal articulations and large-diameter metal heads. Sometimes standard...
radiographs cannot demonstrate osteolysis; therefore, magnetic resonance imaging evaluations should be performed if joint wear is highly suspected.

**What types of implants show the least amount of wear?**

Current data show that the least amount of wear is produced with ceramic-on-ceramic articulations. Modification of cross-linked polyethylene with vitamin E offers similar excellent results, but laboratory data on the long-term clinical results of these materials are necessary.

**What types of implants show the most amount of wear?**

Currently, in standard polyethylene and metal-on-metal articulations, large-diameter heads are most concerning. There have been several large recalls on metal-on-metal THAs and metal-on-metal hip resurfacing.

**What is the time frame in which implants begin to show wear?**

Standard polyethylene articulations in combination with metal heads start to show wear at an average of 10 to 15 years in most implants. Metal-on-metal failures seem to start markedly earlier, many between 3 and 5 years after implantation.

**What methods can be used to decrease the amount of wear on implants?**

The amount of wear on implants is not only related to the material itself. Much responsibility lies with the surgeon. Clinical data have clearly demonstrated that implants inserted correctly have fewer problems than those inserted inadequately. Significant valgus positioning of the cup leads to edge loading, resulting in isolated located wear followed by osteolysis and loosening of the implant. Therefore, it must be concluded that sufficient and long-lasting results can only be achieved with the combination of perfect surgical procedure and adequate selection of articulating materials.

**What research is being done in the tribology of THA implants?**

At the moment, the focus of research is on the improvement of cross-linked polyethylene and on the further improvement of the already excellent wear properties of ceramic articulations. During the past few years, there has been a focus on the option of a metal-ceramic articulation, but so far, the laboratory data have not led to an introduction of this combination, mainly due to concerns about metal wear and its deleterious consequences.

**What does the future hold for the tribology of THA implants?**

I do not foresee completely new materials being introduced in the near future. The current focus of industry is evaluating and possibly improving the current ceramic material and vitamin E–enhanced cross-linked polyethylene. Further investigation is needed into whether the combination of cross-linked polyethylene with a metal head or a ceramic head results in less polyethylene wear. Another focus will be the proper selection of an articulating head size that will provide a balance of maximum stability and minimal wear. Finally, the recent issue of corrosion at the femoral neck of the stem implant needs to be addressed in laboratory examinations and clinical evaluations of current THA systems.