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In hip implants, where wear resistance is key, each combination of bearing surfaces has unique advantages and distinct drawbacks

When it comes to arthritis in the hip joint, patients no longer have to grin and bear it. Instead, hip implants replace damaged natural bearing surfaces with artificial ones in order to alleviate pain and improve quality of life for patients.

Consisting of a stem, femoral head, and an acetabular cup that is frequently outfitted with a liner, the replacement ball-and-socket joint should ideally couple high mechanical strength with range of motion and durability. Wear resistance, however, is the critical property by which bearing surface success is measured.

Surface friction between the femoral head and the liner of a man-made hip prosthesis generates tiny particles of debris, which, in turn, triggers an autoimmune response by the body. Because the debris often settles close to the implant, the body ends up attacking the surrounding bone, resulting in bone loss referred to as osteolysis. Osteolysis is considered to be the primary factor contributing to inflammation, implant loosening, and the eventual need for revision surgery for hip-replacement systems.

The rate at which an implant experiences wear and produces debris is dependent on the bearing surfaces selected for the ball-and-socket portions. Throughout their evolution, hip prostheses have incorporated metal-on-metal (all-metal), metal-on-polyethylene, ceramic-on-polyethylene, and ceramic-on-ceramic (all-ceramic) implant designs, each with its own unique advantages and distinct drawbacks. And new combinations ofâ€”and improvements inâ€”materials are beginning to emerge as well. Despite progress, there is still no clear frontrunner in terms of the perfect bearing surface material combinationâ€”but that doesnâ€™t mean that suppliers and OEMs arenâ€™t trying to figure it out

All-Metal Implants

Metal-on-metal implants have had a history fraught with dramatic highs and lows in the industry. Because the hip is a load-bearing joint, various metals have found favor over the years among implant manufacturers and surgeons alike owing to their exceptional mechanical strength. A trailblazer in the industry, the all-metal implant also set the standard in the early days of hip arthoplasty procedures. These initial designs, however, were sometimes marred by poor process control for casting, inferior designs, and weak structures. As a result, the rise of the better-performing metal-on-polyethylene prostheses supplanted all-metal constructions as the preferred design for several decades.

Use of metal-on-metal designs has been further bolstered by their more-recent success in hip-resurfacing applications. An alternative to total hip replacement, resurfacing entails reshaping the patientâ€™s natural femoral head and then capping it with a metal implant rather than replacing the entire joint. â€œThis [trend] is really surgeon and OEM led,â€• director for Ananta Ortho System Pvt.Ltd observes. â€œIn the case of resurfacing, the logic is very sound: Why sacrifice good bone when only the surface is damaged?â€•

Even though wear rates of polyethylene are relatively low, the generation of any debris poses a threat to patient health. Motivated to improve wear resistance after 45 years without change to the materialâ€™s molecular structure, the plastics industry has been increasingly experimenting with cross-linking of polyethylene in recent years. DSM Biomedical is among the companies exploring highly cross-linked polyethylene. The company recently announced its new platform of easily cross-linkable diene-copolymers, and claims to be the first one to apply the technique to UHMWPE.

Improved wear resistance is indeed achieved through the processâ€”albeit not without consequence. Cross-linking has been shown to decrease the materialâ€™s mechanical strength and oxidative stability, thereby making it susceptible to fracture and failure. The DSM cross-linking platform, on the other hand, minimizes this loss of critical properties,. He states that it enables the development of highly cross-linked UHMWPE using significantly lower doses of radiation than those employed in conventional cross-linking processes.

â€œThe aim of our platform is if you start with our material, you can radiate the material with three to four times less radiation, which means that you induce [fewer oxygen] radicals,â€• . â€œTherefore, the attack of the radicals on the stability of the polymer is much lower, so we expect it to be more stable.â€• Still in the R&D phase, the platform has yielded cross-linked UHMWPE that is 20 to 25% stronger and features two to three times fewer radicals than current cross-linked polyethylenes,. â€œWe have proven these numbers in the laboratory and we are now working with a number of major medical device companies to see if we can then translate that into more-stable and stronger implants.â€•

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