The indications for hip replacement, especially in young patients with end-stage degenerative arthritis of the hip, have increased during the past 20 years. Because of the accelerated risk of polyethylene wear and subsequent prosthetic loosening due to osteolysis, new interest has focused on the metal-on-metal articulation couple. Failures of first-generation metal-on-metal total hip arthroplasties (THAs) are attributed to suboptimal surgical technique, excessive or negative clearance, poor fixation, and neck–socket impingement. Improvements in metallurgical and tribological properties (ie, sphericity and radial clearance) of metal-on-metal bearing couples has led to a renaissance of metal-on-metal resurfacing arthroplasties and THAs. Second-generation metal-on-metal wear rates are noted to be 20 to 100 times lower than metal-on-polyethylene wear rates.

Good clinical and radiological results have been reported after metal-on-metal resurfacing arthroplasties in patients younger than 55 years, with survival rates of 99% and 98% at 10- and 13-year follow-up, respectively. Also, good results have been described after a minimum 6-year follow-up (mean, 5.7 years) of cementless second-generation metal-on-metal THAs in prospective, randomized, controlled clinical trials, with a survival rate of 100%. Few prospective, randomized, controlled studies compare conventional metal-on-polyethylene THAs with second-generation metal-on-metal THAs. Zijlstra et al reported a 10-year survival rate of 95.5% for a metal-on-metal group and a 10-year survival rate of 96.8% for a metal-on-polyethylene group, with no difference in clinical or radiological outcomes. Small bearing couples of 28-mm femoral heads were used.

Interpretation of the results of different prosthetic devices, as well as metal-on-metal resurfacing arthroplasties, is problematic because of differences in design, alloy, radial clearance, risk of head–neck impingement, edge wear, and other metallurgical properties. Besides better metallurgical and tribological properties, orthopedic companies also claim clinical advantages of large-head metal-on-metal THAs over conventional small-head metal-on-polyethylene THAs, including a larger range of motion and a decreased risk of dislocation. However, in a randomized clinical trial, no clinically relevant difference in range of motion was observed between conventional 28-mm metal-on-polyethylene THAs compared with large-head metal-on-metal THAs.

Until now, few prospective, randomized, controlled trials have documented the long-term clinical and radiological results of metal-on-metal resurfacing arthroplasties and metal-on-metal THAs, including survival analysis. No proven clinical advantage of metal-on-metal over metal-on-polyethylene THAs currently exists. Future research should focus on long-term follow-up of the new generation of hip replacements.

Recently, concern has emerged about the development of pseudotumors in large-head metal-on-metal THAs and resurfacing arthroplasties. These pseudotumors, also known as aseptic, lymphocyte-dominated, vasculitis-associated lesions or adverse reactions to metal debris, are caused by a local metal allergy or sensitivity and a type IV, local, delayed-type hypersensitivity caused by T lymphocytes. Even with low wear rates, this type of allergy can develop. Whether aseptic, lymphocyte-dominated, vasculitis-associated lesions are specific to metal-on-metal implants is under investigation.

More lymphocytes and plasma cells and fewer macrophages are found in tissue reactions in metal-on-metal THAs compared...
with metal-on-polyethylene THAs. This histological difference may be attributed to the difference in size between polyethylene (several micrometers) and metal particles (submicron- and nanometer-size particles). The reported incidence of symptomatic pseudotumors varies. Pseudotumors can be caused by the local periprosthetic deposition of cobalt and chromium particles, sometimes resulting in soft tissue masses in the groin area; pain, swelling, and discomfort in the leg; or compression of the neurovascular bundle. Whether the production of metal particles is caused by wear of the bearing couple itself, such as edge wear in large-head metal-on-metal THAs and metal-on-metal resurfacing arthroplasties, or at the taper–head connection, such as in large-head metal-on-metal THAs, is under investigation. Small-diameter components used for women and adolescents and a high inclination of the acetabular component could be significant risk factors in pseudotumor formation.

Due to periprosthetic pseudotumor formation and a high failure rate, the Articular Surface Replacement (DePuy, Johnson & Johnson, Leeds, United Kingdom) was withdrawn from the market. Results from the registries from Australia, England, Wales, and New Zealand demonstrated an overall increased rate of revision arthroplasty in metal-on-metal THAs and resurfacing arthroplasties. In my experience with a recall of 143 resurfacing Birmingham Hip (Smith & Nephew, Memphis, Tennessee) arthroplasties in 125 patients, computed tomography scans showed a pseudotumor in 40 (28%) hips. In 11 of the 40 cases, patients had pain, swelling, and discomfort in the groin area and either had already undergone or are currently scheduled for revision. Patients with pseudotumors had significantly increased serum chromium and cobalt ion levels.

Contrary to the micrometer-sized polyethylene particles in conventional articulations, metal particles generated in metal-on-metal bearings are nanometer sized. These ultra-small particles cause less granulomatous inflammation but are produced in greater numbers. This can lead to a greater release of osteolytic enzymes compared with large polyethylene particles, which results in granulomatous giant cell formation with less release of osteolytic mediators. Nanometer-sized metal particles can corrode in synovial fluid, forming cobalt and chromium ions. After particle corrosion, the serum level of chromium and cobalt ions is elevated. The clinical consequence of elevated chromium and cobalt ions is systemic pseudotumor. According to the British Orthopaedic Association, revision should be considered in the presence of pain, high cup inclination angle, and elevated metal ion levels. It can be argued that, in the presence of pain and high inclination angles, revision should be considered anyway. In cases of severe tissue reaction and large pseudotumors, revision surgery can be complex, with extended soft tissue damage. So far, the results of revisions of failed metal-on-metal resurfacing arthroplasties and metal-on-metal THAs have been good in the short term, but results after long-term follow-up are not available, especially in hips that were revised because of pseudotumor formation.

Long-term results of conventional metal-on-polyethylene THAs are excellent. Until now, second-generation metal-on-metal THAs and metal-on-metal resurfacing arthroplasties have had varying mid- and long-term results. Until long-term results of these new types of hip implants are available and more is known about the local and systemic effects of this generation of metal wear particles and ions, the gold standard will be the metal-on-polyethylene articulating couple. According to the advice of the Dutch Orthopaedic Society, I would also recommend delaying the implantation of metal-on-metal THAs and resurfac-
ing hip arthroplasties until more is known about the safety and long-term results of these implants.

Given the recent European experiences with metal-on-metal THAs and metal-on-metal resurfacing arthroplasties and the results from the registries of Australia, England, Wales, and New Zealand, new types of implants should be introduced in unbiased, clinical, double-blind, prospective trials with the informed consent of patients and according to the rules of the local ethical committee and registration in the national trial registry. A need exists for well-designed, prospective, randomized studies and high-level systematic reviews, as well as national joint registries to assess innovations in joint replacement. Only in this way can the potential advantages and disadvantages of introducing new techniques be assessed with the best possible scientific evidence.

REFERENCES