Ceramics instead of chromium

Although artificial hip joints last for around 20 years, you can't replace them as often as you like. Together with the Swiss ceramic component manufacturer Metoxit, Empa scientists are looking to postpone joint replacements for as long as possible using a kind of protective cap.

TEXT: Letizia Krummenacher / PICTURES: Empa

Arthrosis in the hip joint is not just painful; it increasingly restricts the patient's freedom of movement. The last resort is often a prosthetic hip. Today, such a joint replacement lasts for 20 years on average. The most common cause for a replacement's failure is the so-called aseptic loosening of the artificial joint. In other words, it starts to wobble, which means that the joint needs to be replaced with a new one. With the shaft prostheses used in the hip today, however, this procedure cannot be repeated too often. This is because the entire femoral neck bone already needs to be removed for the first shaft prosthesis and the surgeon has to keep drilling further into the bone tissue for every additional prosthesis. Eventually, the "bone wall" becomes too thin.

"Resurfacing prostheses" were developed a number of years ago to preserve the femoral neck bone for as long as possible if the hip joint is damaged. To attach them, only the surface of the bone is milled off and a cap – the hip resurfacing – is placed directly on the femoral head. The corresponding socket (which also needs replacing) is anchored in the hip bone above. The advantage for patients: the thigh's bone substance remains intact.

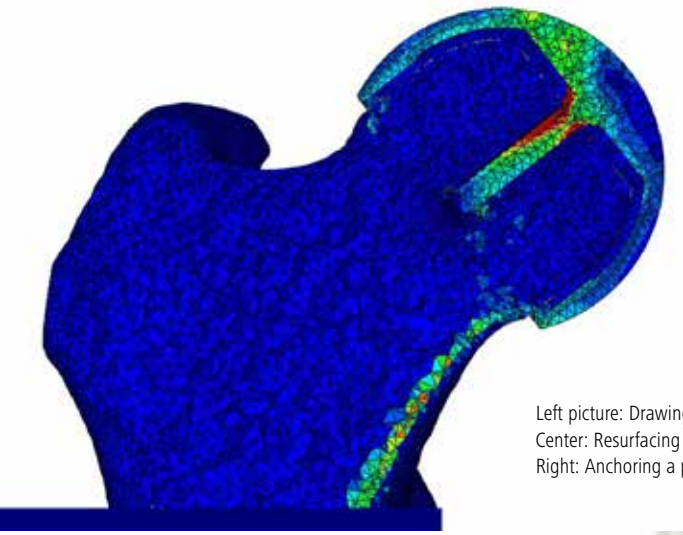
Metal in the bloodstream

However, resurfacing prostheses consist of a cobalt chromium alloy and often pose problems: when the metal surfaces of the hip resurfacing and the socket slide against each other, metal particles can enter the body, which can cause allergies, inflammations, necrosis or even poisoning.

In order to solve the problem, the Swiss company Metoxit teamed up with Empa to develop a new ceramic prosthesis. But not the ceramics used in flower pots or roof tiles. Unlike such low-tech ceramics, high-strength mixed ceramics made of zirconium oxide and aluminum oxide, also known by the abbreviation ATZ (alumina-toughened zirconia), are used for the new prostheses. Metoxit developed this extremely strong, hard and long-lasting high-performance ceramic material and is already using it successfully in dental implants. Compared to metal alloys, the material is more wear-resistant. Moreover, its good biocompatibility reduces the risk of immunological reactions, even if there were some wear.

Best possible fixation

Bernhard Weisse and Sebastian Valet developed and optimized the design and macrostructure of the new ceramic prostheses. Unlike the modular systems available today, the hip resurfacing and the cup



Left picture: Drawing of a hip resurfacing prothesis.
Center: Resurfacing prothesis (above) compared to a shaft prothesis.
Right: Anchoring a prototype in artificial bone material.

are produced in a single piece, which makes the prosthesis much easier to insert. But the design also needs to guarantee the best possible fixation. “To do so, several rims with a profile of a fluke are cut and turned into the surface of the cup, which dig into the surrounding pelvic bone after being inserted,” explains Weisse. This guarantees good basic stability from the very beginning. On the opposite side, the surface of the femoral head is milled so that the cap merely needs to be placed on top and immediately holds in place.

Testing with bone precursor cells

For the prosthetic to remain stable in the long term, however, bone cells need to be able to adhere and proliferate on the surface. In order to find a suitable surface structure Katharina Maniura and her team at Empa are conducting cell assays on a rough, porous surface where bone precursor cells can multiply. The surface is based on structures, with which dental implants already grew into the jaw bone. Nevertheless, bone cells from different regions of the body differ greatly. The next step will, therefore, be to adapt the implant surface to the special requirements of hip bones. //

Bernhard Weisse using a traction device to check how firmly the prosthesis can be anchored in artificial bone material. The design of the grooves and barbs is crucial.