2.3 Hip Resurfacing – a superior articulation concept?

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Introduction

Hip Resurfacing is an idea and concept dating back to the end of 1800’s and restarted with metal components by Wiley around 1938. The concept of using a thin bearing only covering the affected surface of the hip instead of a total hip arthroplasty (THA) is intriguing. The big diameter implant restores the normal anatomy. Compared to a THA it increases the range of motion and reduces the risk for impingement. The overall stability of the hip joint is improved and the stemless femoral component of the arthroplasty saves bone stock for a later revision. Several attempts with Surface Replacement (SR) arthroplasty have been made historically with various designs and materials, an example shown in Figure 1. First metal-on-metal (MoM) was used, then plastic- or ceramic-on-metal and even ceramic-on-ceramic. All these historic couples failed already in the short-term, either due to surgical issues, lack of permanent fixation, necrosis, deformation with high friction and reaction to wear particles.

The renaissance of the resurfacing concept has been started after the re-introduction of the MoM articulation for THA in 1989 [1]. Because the low wear and the high strength and stiffness of the CoCr alloy allowed for thin components the concept of SR was re-evaluated. Apart from improved joint stability it was thought that tribological a large diameter bearing would allow developing a permanent lubrication film to separate the articulation metallic surfaces during the patient’s activity from each other and, thereby reducing the friction and also the wear.

Permanent and continuous lubrication in a human joint is difficult to achieve with its varying force and velocity, a turning point at zero velocity and the individual lubrication regime during a walking cycle and tiny wear particles are released into the local tissue. If a MoM concept is used metal wear products can be detected not only in the peri-prosthetic tissue but also in distant organs like liver, spleen and lymph glands [2,3]. Due to the dissolution of the metal in the body environment ions are released, distributed throughout the body creating
potential biological issues. A reduction in the wear rate, especially the high running in wear in the early phase of the ambulation is, therefore important for the long-term success of THA and SR.

**Material and Methods**

A series of hip joint simulator studies with various MoM couples was conducted. The specimens were manufactured from Co-28Cr-6Mo-0.2C alloy. A total of 27 MoM combinations were fabricated and investigated using two different hip joint simulators and test protocols.

The first set of experiments was conducted using a MTS 8 station hip joint simulator in 50% diluted bovine serum. First, two conditions (cast and cast/solution annealed) of the CoCr-alloy with 40 mm diameter articulation were compared and a second generation MoM THA with 28 mm diameter used as control in a short 1 million cycle test. The as-cast components had an average grain size of 1-2 mm with hard M$_{23}$C$_6$ and M$_7$C$_3$ (M = Co+Cr+Mo) carbides of approximately 20 µm diameter embedded in the matrix. The 28mm articulations were manufactured from hot worked (WF) CoCr-alloy with an average grain size of 20 µm and carbides of 2-3 µm.

Subsequent experiments tested the consistency of the early results using a set of as-cast 40 mm diameter articulations with a radial clearance of 50-90 µm for 5 million cycles. The test was repeated then with another set of 40 mm diameter articulations with a lower radial clearance of 25-50 µm.

A final experiment was conducted using a commercial SR implant of 50 mm in a physiological anatomical Leeds I PA simulator for 5 million cycles. Comparative wear control data was obtained from a previous test using the same simulator and protocol for a commercial 28 mm THA bearing [4].

**Results**

The result of the comparison between two different types of cast 40 mm diameter MoM articulations and conventional MoM THA of 28 mm is depicted in Figure 2. The average wear rate at 1 million cycles for the solution treated 40 mm bearings was about four times that of the as-cast bearings, indicating that the presence of carbides plays a significant role in the wear performance of MoM joints. Interestingly, the second generation MoM (28 mm) wore less only a non significantly different rate compared to the first generation as-cast bearings (p = 0.29) despite the difference in the diameter and material.

![Figure 2: Hip simulator wear rate of MoM articulations.](image-url)