# Effect of Surface Processing of Co-28Cr-6Mo Alloy on Wear Behaviour of Ultra-high Molecular Weight Polyethylene in Artificial joint

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*The effects of surface texturing on Co-Cr-Mo alloy on the wear behaviour of ultra-high molecular weight polyethylene was investigated using pin-on-disc wear testing. The surface roughness of the texture ranged from the micrometer to the nanometer scale, and a waviness curve with convex and concave parts of millimeters in size. The surface processing was conducted using micro slurry-jet erosion. The textured surface of Co-Cr-Mo alloy reduced the number of polyethylene wear debris and enlarged the equivalent circle diameter of the debris compared with a conventional mirror finish surface. To investigate the phagocytosis of the wear debris by human monocyte-derived macrophages and the secretion of inflammatory cytokines, a microchamber was fabricated, and quantitative and time-dependent assessments were performed. Administration of culture medium with no polyethylene particles was used as a negative control, for which the secretion of TNF-α was not detected. With increasing administration of the polyethylene particles, the secretion of TNF-α gradually increased. TNF-α secretion was influenced by polyethylene particle size. The results suggested the possibility of reducing the major factors in the long-term osteolysis and loosening of artificial joints through surface texturing.*

### NOMENCLATURE

Co = cobalt
Cr = chromium
Mo = molybdenum

## 1. Introduction

Osteolysis and aseptic loosening in hard-on-polymer artificial joints are attributed to the discharge of micron- or submicron-sized fine polyethylene wear particles. Some studies have indicated that small-sized debris (< 1.0 μm) is the most biologically active. A polymer-on-hard joint lubricated using a joint fluid is characterized by a boundary or mixed lubrication mode. Hence, polyethylene wear is inevitable. Therefore, a smoother alloy or ceramic surface is essential for reducing the volume of polyethylene debris owing to a shift in the wear mode from abrasive to adhesive wear. However, in this case, the debris size of polyethylene was smaller, thereby inducing macrophage activation.

In this study, the effects of surface texturing, which could reduce the amount of polyethylene wear debris and enlarge the equivalent circle diameter of the debris in comparison with a conventional mirror-finish surface, were investigated.

## 2. Materials and Methods

Polyethylene wear debris was generated using a pin-on-disc wear machine (Fig. 1). A pin made of polyethylene was pressed onto a disc made of Co-28Cr-6Mo alloy. The pin was fixed with a holder jig, and the disc was subjected to orbital motion. This could demonstrate the multidirectional pathways for the pin surface.

Fig. 2 shows a schematic of the micro slurry-jet erosion used for surface texturing on a Co-Cr-Mo alloy[1)]. Micro-slurry-jet erosion is a wet-blasting technique that uses alumina particles as abrasive media along with compressed air and water. The nozzle and stage can be moved orthogonally parallel to the Co-Cr-Mo alloy surface using mechanical control. A textured surface was obtained by adjusting the feed speed and pitch of the nozzle. A polished surface obtained using the conventional lapping method was used as the conventional surface.

To investigate the phagocytosis of polyethylene wear de-bris by human monocyte-derived macrophages and secretion of inflammatory cytokines, a microchamber was fabricated (Fig. 3) [2]. The chamber had inlet and outlet ports for continuous administration of the culture medium with wear debris. These configurations enabled the wear debris to pass near the macrophages and enabled quantitative and time-dependent assessments.

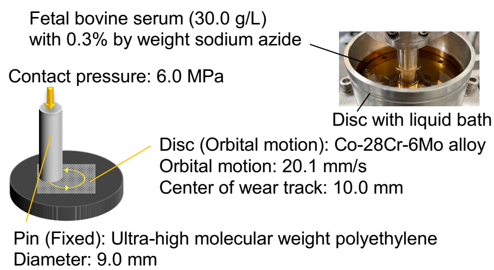


Fig. 1 Pin-on-disc wear machine.

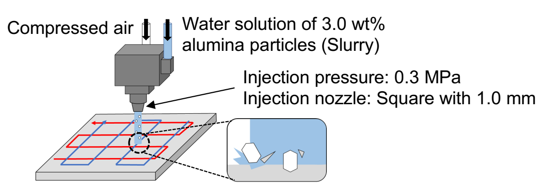


Fig. 2 Micro slurry-jet erosion.

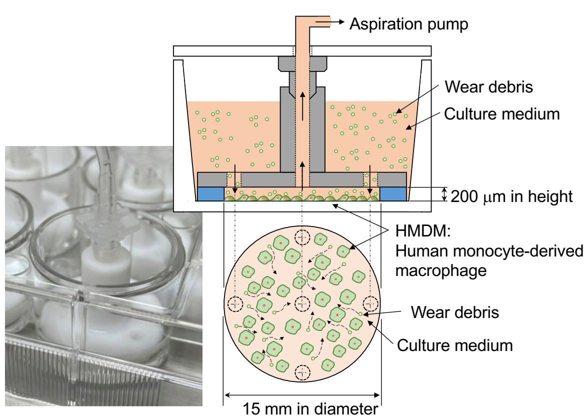


Fig. 3 Microchamber.

## 3. Results and Discussion

Fig. 4 shows the surface profiles of the Co-Cr-Mo alloy discs used for the wear tests. The textured surface had a waviness curve with convex and concave parts of millimeters in size.

Fig. 5 shows the amount of wear debris and the morpho-logical aspects of wear debris. We confirmed that the textured surface of the Co-Cr-Mo alloy reduced the amount of polyethylene wear debris and enlarged the equivalent circle diameter (D), aspect ratio (R), and complexity (C) of the debris in comparison with a conventional mirror finish surface.

Fig. 6 shows the secretion of TNF-α by administration of wear debris. Administration of culture medium without polyethylene particles was used as a negative control, for which the secretion of TNF-α was not detected. With increasing administration of polyethylene particles, the secretion of TNF-α gradually increased. TNF-α secretion was influenced by polyethylene particle size. The results suggest the possibility of reducing the major factors in the long-term osteolysis and loosening of artificial joints through surface texturing.

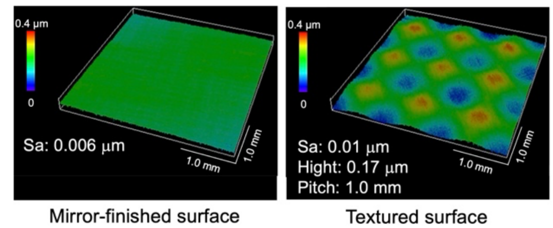


Fig. 4 Surface profiles of the Co-Cr-Mo alloy discs.

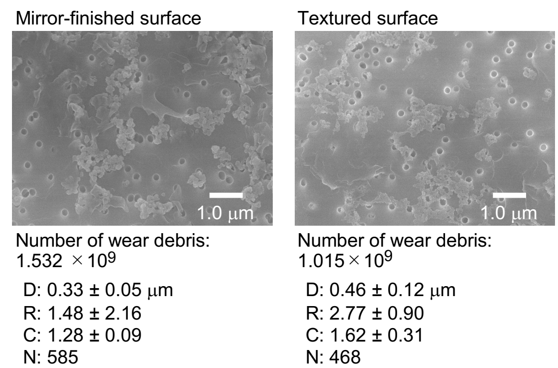


Fig. 5 Number of wear debris and their morphological aspects. D: Equivalent circle diameter, R: Aspect ratio, C: Complexity, N: Number of particles for calculation for these parameters.

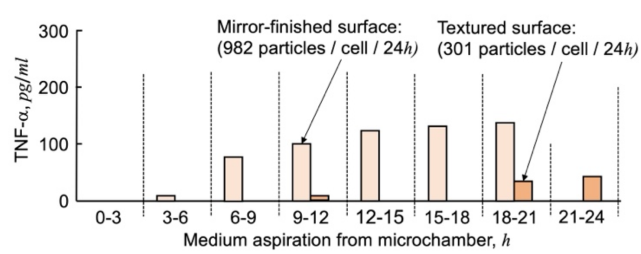


Fig. 6 Secretion of TNF-α by administration of wear debris.

## ACKNOWLEDGEMENT

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## REFERENCES

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