ABSTRACT

The lumbar disc is a cartilage disc in the lower spine that separates the vertebrae. The lumbar disc has a function as a lubricant, protects the joints, and increases the flexibility of the lower spine. Injury to the lumbar disc causes pain so that sometimes requires replacement. The lumbar disc implant design is generally a ball on socket pair, but there is a risk of wear that results in debris, which can endanger the surrounding tissue. Efforts to improve the wear resistance of ball on socket pairs are continuously being made, including by shifting the ultra high molecular weigh polytelene (UHMWPE) center of radius (CoR) ball to the socket endplate. Currently, the CoR is always positioned at the center of the disc, which is at the center of the polyethylene core. The material used for lumbar disc implants must be biocompatible. The casting method is often used to manufacture implants because it is capable of making products with complex shapes, precise sizes, and smooth surfaces. The design of the gating system on casting must be done to produce products as needed. This research aims to study the casting process for making sockets and test the wear of ball on socket pairs for commercial pure titanium (CP-Ti)-UHMWPE and stainless steel (SS) 316L-UHMWPE.

The materials used in the research were CP-Ti, SS 316L, and UHMWPE. CP-Ti and SS 316L socket specimens were made by investment casting. During the manufacture of CP-Ti sockets, the pouring of liquid metal was carried out by the centrifugal method, while the SS 316L sockets were carried out by the gravity method. The characterization of the socket includes porosity, density, hardness, microstructure, and surface roughness. The tribotester (spine simulator) wear test was carried out on the ball on socket pairs of CoR variations (7.5, 9, 11, and 13 mm) up to 1 million cycles with dynamic loading of 50-150 N in bovine serum fluid.

The results showed that the CP-Ti socket produced by centrifugal casting with a square section oblique gate at an angle of 60º (the same as the mold rotation) resulted in a socket with the least shrinkage cavity (0,34%), the highest density (4,519 g/cm^3), and the lowest roughness (3,9 µm). On the other hand, oblique gate at an angle of 150º (opposite with the mold rotation) resulted in a socket with the highest shrinkage cavity (0,92%), the lowest density (4,510 g/cm^3), and the highest roughness (5,5 µm) among the gate with an angle of 30º up to 150º. Meanwhile, the SS 316L socket produced by investment casting using the gravity method, which is poured in different positions, has almost the same characteristics. Variations in the CoR of the ball on socket pairs have an influence on the wear rate, wear factor, and surface roughness. The wear rate and wear factor increase with the increase in CoR, whereas the surface roughness decreases with the increase in CoR after reaching 1 million cycles. The performance-compliant CoR design for lumbar disc implants is the 7.5 mm CoR spacing for UHMWPE/Cp-Ti, while the CoR spacing for UHMWPE/SS316L pair are 7.5, 9, and 11 mm.

Keywords: lumbar disc, wear factor, center of radius, centrifugal, CP-Ti, SS 316L, UHMWPE