

THE EVALUATION OF TRIBOLOGICAL PROPERTIES OF BIOMATERIALS USED FOR KNEE REPLACEMENTS

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INTRODUCTION

No known surgical implant material has ever been shown to be completely free of adverse reactions in the human body. However, long-time clinical experience of use of the biomaterials has shown that an acceptable level of biological response can be expected, when the material is used in appropriate applications. This article deals with very specific wear resistance testing of biomaterials used for producing of surgical implants. This type of testing is very important for appreciation of new directions at the joint replacement design (for example in total knee replacement). The aim of this work is to evaluate the influence of different type of biomaterials and modification of UHMWPE (Ultra High Molecular Weight Polyethylene) on the wear resistance. The special experiments were carried out in collaboration with The Academy of Sciences of the Czech Republic and company MEDIN ORTHOPAEDICS Inc.

MATERIALS AND METHODS

The special wear resistance tests, called "Ring On Disc", were completely carried out with a lot of pairs of different biomaterials. The experiments were executed according to ISO 6474:1994(E). This International Standard deals with evaluation of properties of biomaterials used for production of bone replacement. The method is based on loading and rotating two pieces from biomaterials (see Figure 1).

A ring is loaded onto a flat plate from different material. The axial load that is applied on the ring is all the time constant and equal 1500 ± 10 N. The ring is rotated through an arc of $\pm 25^\circ$ at a frequency of (1 ± 0.1) Hz for a given period of time (100 ± 1) hours. There is distilled water using as the surrounding medium.

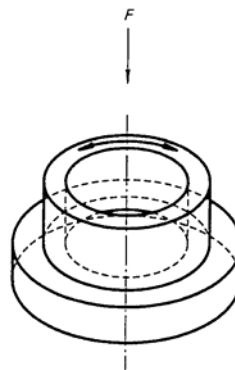


Figure 1: Schematic diagram

As a measure of wear resistance is determined and used volume of the wear track on the disc. The wear track cross-sectional area is analyzed from measured profile for each disc alone. The volume of the track is calculated

from this area. After that the average volume is calculated for one group of specimens.

The profile measurements of the tested specimens were carried out using a specially adapted assembly. To determine the vertical position of points on the disc was used the digital drift sight MAHR EXTRAMESS 2001, with the sensitivity of $0.2 \mu\text{m}$, placed in a sufficiently stiff stand. A positioning cross-table (ZEISS), containing a make-up piece (in which the disc was inserted), served for the disc shifting. The cross-table is movable in two axes by means of two

micrometric screws. Measured data were registered in a table prepared in advance.

The Experiments were carried out on the top quality testing system MTS 858 MINI BIONIX placed in “Laboratory of Biomechanics” at the Czech Technical University in Prague, Faculty of Mechanical Engineering, Department of Mechanics, Biomechanics and Mechatronics.

RESULTS AND DISCUSSION

The evaluation of the wear resistance was addict on the pertinence of different type of biomaterials and modification of UHMWPE. Totally the tests were executed in “Laboratory of Biomechanics” with 6 groups of specimens from different materials. There were 5 tested pairs in each group (means 6x5x100 hours of testing). The final parameters obtained in these tests - the wear volumes - were calculated (see Table 1). The comparison of different combinations of biomaterials used for implants producing can be implemented from this analysis.

CONCLUSIONS

We obtained the objective information about wear resistance for 6 combinations of different biomaterials and their modifications. The resulting wear volume indicates the amount of elements that are loosening during loading of the bone

substitute implant in human body and describes one from the mechanical properties.

We found out the worn volume on the UHMWPE modified by crosslink is less than on the UHMWPE without modification and less then other combinations of biomaterials too. The results show the modification by crosslink is for UHMWPE material useful. Only wear resistance of combination ceramics x ceramics is better, but this combination is used only for comparison now. For next development it is purposeful to finish tests with other bone-substitute materials and increase the database with wear resistance evaluation.

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Table 1: The final parameters of mechanical testing.

| Material of RING | Material of DISC | Wear volume [mm ³] |
|---|-----------------------------|--------------------------------|
| Zirconia ceramics (Y-TZP) | Alumina ceramics | 0,16 |
| Vitalium alloy (Co-Cr-Mo) | Crosslink UHMWPE | 4,78 |
| Vitalium alloy (Co-Cr-Mo) | UHMWPE | 5,51 |
| Alumina ceramics (Al ₂ O ₃) | Pressed UHMWPE | 5,62 |
| Titanium alloy (Ti ₆ Al ₄ V) with DLC | UHMWPE | 6,61 |
| Zirconia ceramics (Y-TZP) | PEEK (PolyEtherEtherKetone) | 7,59 |