WEAR RATE COMPARISON BETWEEN ADDITIVE MANUFACTURED AND CASTED FEMORAL COMPONENTS

Ana Laura Puente Reyna (1), Jens Schwiesau (1, 2), Thomas M. Grupp (1, 2)

1. Aesculap AG, Research & Development, Germany; 2. Department of Orthopaedic and Trauma Surgery, Musculoskeletal University Center Munich (MUM), Campus Grosshadern, LMU Munich, Munich, Germany

Introduction

Additive manufacturing technology has shown important advances in recent years, which has helped increase its popularity in the orthopaedic field. The applications where this technology is currently being used include preoperative planning (1), patient specific cutting guides (2) and custom made implants (3).
Moreover, 3D printing has also been used for large scale manufacturing of some titanium implant components, such as cones (4), spinal cages (5) and cementless tibial components (6), from which there are even clinical results found on the literature.
Nevertheless, few literature covers 3D manufacturing of CoCrMo femoral components for total knee arthroplasty (TKA), and when it does, it is focused on custom made implants for patients with severe cases. These types of implants should also undergo pre-clinical testing in order to assure their mechanical properties. However, it is mainly focused on its fatigue testing (3), and not on its wear behaviour while articulating against an ultra-high-molecular weight polyethylene (UHMWPE) gliding surface.
Furthermore, as 3D printing is a faster and cost saving technology during the development phase of an implant, it could also be used to evaluate the wear behaviour of several femur designs without the need of investing in the expensive moulds and tools required to fabricate casted implants. However, there are no studies that confirm that 3D printed implants generate the same amount of wear as casted implants.
The purpose of this study is to compare the wear behaviour of an additive manufactured CoCrMo femoral component to the wear behaviour of a standard casted CoCrMo alloy femoral component.

Methods

Four medium size femoral components based on the Columbus® CR design (Aesculap AG, Tuttlingen, Germany) were additive manufactured out of CoCrMo (AM group). For the comparison group, four femurs from the clinically established casted CoCrMo alloy version of the femur implant (cast group) were selected. For both groups, the same UHMWPE gliding surfaces (Columbus® DD, size T3, high 10 mm) and tibial components were used.
Wear simulation according to ISO 14243-1 was performed on a load controlled 4 station knee wear simulator (EndoLab GmbH, Germany). The gliding surfaces were first be tested for 3 million cycles while articulating against the cast alloy femoral components. Afterwards, the same gliding surfaces were be tested for 3 million cycles while articulating against the additive manufactured femoral components.

Results

Before testing, the additive manufactured femoral components were analyzed in order to verity that they comply with the specifications of the drawing (specifically their roughness at the articulation surface and their geometry).
Wear rate of the UHMWPE gliding surface was calculated taking into account the 3 million cycles that each tested group underwent. An statistical analysis was performed in order to determine if there is a significant difference in the wear rate between both groups.
An analysis of the articulating surfaced (femoral components and gliding surfaces) was performed with a microscope in order to determine if both groups shoed similar wear modes.

Discussion

Additive manufacturing is a versatile technology that helps to provide TKA implants for patients with severe cases as well as a tool during the development phase that can help save costs and time. However, it is important to assure that the wear behaviour of the UHMWPE gliding surfaces articulating against additive manufactured femoral components is not compromised.

References

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