Investigation on the biological functioning of the Pyrocarbon in the context of the orthopaedic arthroplasty compared to the cobalt chromium

A. Hannoun[1], G. Ouenzerfi[1,3], L. Brizuela[2], S. Mebarek[2], C. Bougault[2], M. Hassler[3], Y. Berthier[1] and A-M. Trunfio-Sfarghiu[1]

[1]. Univ Lyon, INSA-Lyon, CNRS UMR5259, LaMCoS, F-69621, France
[2]. ICBMS CNRS UMR5246, University Lyon 1, Lyon, France
[3] Wright Medical/Tornier, Grenoble, France

Type of contribution desired: ■ **ORAL** ☐ **POSTER**
■ Candidating to best presentation award for PhD students/young scientists*?
(*PhD defense in 2018 or before the end of 2019".

Keywords: Pyrocarbon, Cobalt-chromium, cartilage, bioreactor, cell culture, biological characterization, mechanical characterisation

ABSTRACT

In the context of shoulder surgical replacement, a new generation of spherical interposition implants made with pyrocarbon (PyC) has been developed. The implant is a mobile spacer rubbing against the glenoid cartilage and humeral bone cavity. Clinical evaluations and radiographic outcomes of the new implant are assessed at the 2-year follow-up by Garret et al. (2017) and Hudek et al. (2017). Both studies reveal satisfactory clinical results and suggest that PyC induce minimal bone and cartilage wear. In a study on human explants, a neosynthesised tissue at the extremity of the humeral metaphyseal cavity in contact with PyC implant is observed (Beckenbaugh et al., 2006). Histological analysis suggests that this new tissue has cartilage-like characteristics. Thus, the capacity of the implant to preserve cartilage integrity or, at least, to prevent more cartilage degeneration is a source of concern. For this reason, the first part of the present study focused on the interaction between PyC and chondrocytes in a cartilage-like environment and bone-like environment (CLC or BLC).

The first aim of this study was to compare PyC versus the most used biomaterial in shoulder arthroplasty: cobalt-chromium (CoCr) implants, regarding preservation and regeneration of the surrounding tissues. The effect of the biomaterials on chondrocytes was analysed in vitro. Murine primary chondrocytes were grown on discs made of PyC or CoCr using two culture media to mimic either CLC or BLC. Chondrocytes did grow on PyC and CoCr without alteration in cell viability or manifestation of cytotoxicity. The tissue-like cell membranes grown under BLC were examined for the chondrocyte's ability to mineralise and for their mechanical properties.

For the chondrocytes grown under CLC and BLC, extracellular matrix components were analysed by histological staining and immunolabelling. Under CLC, PyC promoted type II collagen expression in chondrocytes, suggesting that they may generate a more cartilage-like matrix than samples grown on both CoCr and plastic control. In BLC, the tissue-like cell membranes grown on PyC were more mineralised and homogenous. The mechanical results corroborated the biological data, since the elastic modulus of the tissue-like cell membranes developed on the PyC surface was higher, indicating more stiffness. Overall, the results suggested that PyC might be a suitable biomaterial for spherical interposition implants (Hannoun et al., 2019).

The second part of the study is based on the assumption that the mechanotransduction is an important aspect to provide suitable conditions for cartilage bioengineering process. For this reason a new concept of a bioreactor has been developed. The prototype allows applying tribological solicitations to cell or organ cultures with the possibility of microscopic observation. It solicits separately or simultaneously in compression or in shear cell/organ cultures, which are immersed in a specific culture medium to maintain a suitable biological environment. The second aim of this study, which is currently underway, is to validate this device for cell culture in the presence of PyC interfaces. Compared with a classic rheometer this device is validated for mechanical characterization. The two parts of the present study lead to the overall aim of the project which is reproducing the *in vivo* contact of the PyC, in the context of the interposition shoulder arthroplasty, *ex vivo* as an assumption to better understand the good functioning of this biomaterial.