Introduction

S53P4 Bioactive glass (BAG) granules are biomaterials that are currently used in the treatment of bone infections. They consist of 53wt% SiO$_2$, 4wt% P$_2$O$_5$, 23wt% Na$_2$O and 20wt% CaO. When the material gets in contact with (body) fluid it will immediately start releasing ions (Na$^+$, Ca$^{2+}$, PO$_4^{3-}$, Si$^{4+}$) and it is believed that the increase in pH and osmotic pressure due to this ion release gives rise to the antibacterial nature of the material (Fig. 1) [1]. Although bacteria die in these conditions, it is suggested that the released ions may have a positive effect on human cells that are involved in bone healing and remodeling [2]. One of the suggested effects is the stimulation of angiogenesis, which is the sprouting of blood vessels. Blood vessel ingrowth is needed in bone healing because it will bring nutrients and oxygen to the cells in the center of the construct. These distances are usually too large for diffusion, resulting in dying cells in the center of a filled bone defect. Little is understood about the direct effect of released ions by BAG on cells involved in bone healing (e.g. mesenchymal stem cells (MSCs)) and their relation to stimulate blood vessel growth by endothelial cells (ECs).

Project

In this project a microfluidics device will be developed and optimized to study the effect of the ions released by BAG on human cells. The exposure to ions from BAG to MSCs will be done with conditioned medium. It is hypothesized that this will stimulate those cells to secrete factors that will initialize development of interconnected, vessel-like, structures by ECs (Fig 2) without the need for direct cell-cell contact. The device therefore needs to contain channels dedicated for the two different cell types and by the addition of a hydrogel between these cell types restrictions can be applied (e.g. diffusion of angiogenic factors only, or direct cell-cell contact). A possible design is shown in Fig. 3. One of the main challenges of optimization of the design is to inject the hydrogel such that it does only fill that channel (channel 3 in Fig. 3). The optimization should be performed for at least two different hydrogels; one that does allow for cell migration and cell-cell contact and one that does not (but allows for diffusion of the secreted factors).

This will be a project in close collaboration with the Orthopaedic Biomechanics group (OPB) of the Biomedical Engineering department at the TU/e.

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References