Osteoconductivity of UHMWPE fabric for a cervical artificial intervertebral disc : in vitro analysis

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Experimental set-up

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Introduction

Cervical artificial intervertebral discs (AIDs) have been developed as a mobility preserving alternative treatment for disc degeneration. Clinical results of existing AIDs have moderate success rates and several limitations still exist. It is hypothesized that these limitations arise from the unnatural mechanism of current AIDs, and that mimicking the native structure of the intervertebral disc (IVD) would lead to appropriate biomechanical properties and less complications. As a result, a novel biomimetic AID was developed as shown in Fig. 1. The design contains a hydrogel core, representing the swelling nucleus pulposus, an ultra-high-molecular-weight-polyethylene (UHMWPE) fiber jacket mimicking the annulus fibrosis. Although a metal endplates with pins is used to achieve initial stabilization to the vertebrae, direct anchorage or osseous integration

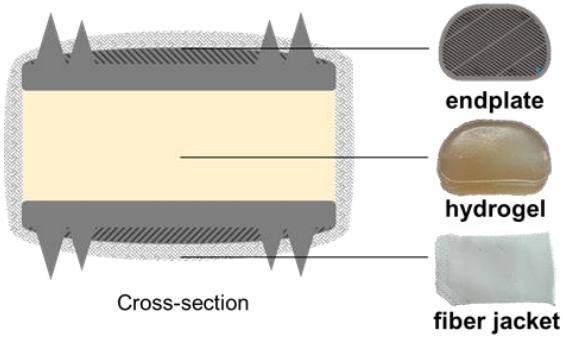
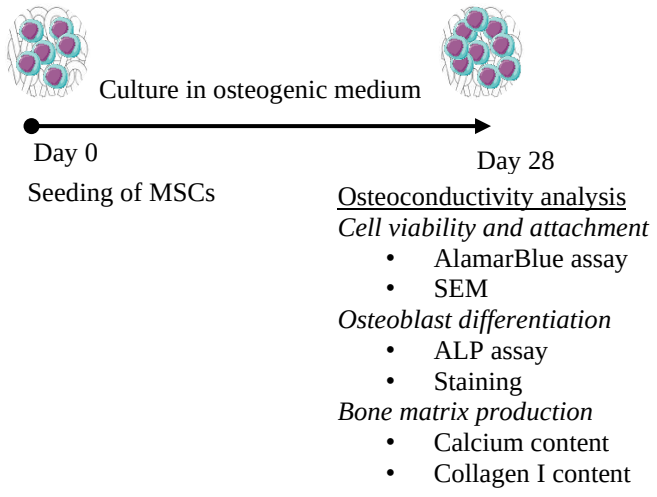


Figure 1: schematic representation of mimetic design.

of the UHMWPE fibers to the adjacent bony structures is required to achieve proper biomimetic function. Although it is very strong, the disadvantage of UHMWPE is that it is inert, and therefore does not allow for sufficient osseous integration. A common approach to achieve a more stable and faster osseous integration is applying surface treatments or by using a known osteoconductive material. Therefore, the aim of this study is to determine the differences in osteoconductivity of different surface treatments of UHMWPE fabrics in comparison with a fabric made from a novel osteoconductive UHMWPE fiber.

Experimental set-up

Six experimental groups (each n=6) will be tested and compared (Fig. 2 right), i.e. 2D knitted fabrics made from: non-treated UHMWPE, osteoconductive UHMWPE, plasma etched UHMWPE, plasma etched osteoconductive UHMWPE, hydroxyapatite (HA) coated UHMWPE; and a pure HA disc (positive control). Plasma etching is known to create a more hydrophilic environment, being favorable for cell attachment. HA is an often-used coating additive because of its biocompatible and osteoconductive properties.
In this research, an osteoconductive material is defined as a material that facilitates bone growth on its surface. New tissue formation on a material is mainly promoted by a surface structure that promotes cell proliferation and production of extracellular matrix. As a result, osteoconductivity will be graded based on three characteristics; cell viability and attachment, osteoblast differentiation and bone matrix production. To assess the differences based on these three characteristics, a static '2D' culture using mesenchymal stromal cells for 28 days will be performed. After 1 and 28 days, cell attachment on the surface will be assessed using scanning electron microscopy (SEM) and cell viability with an AlamarBlue assay. After 28 days, osteoblast differentiation will be verified using alkaline phosphatase activity assay, and staining for osteoblast specific markers osteopontin and osteocalcin. Bone matrix production will be determined with a calcium and collagen I (HYP) assay. A schematic overview of the experimental set-up is shown in Fig. 2.



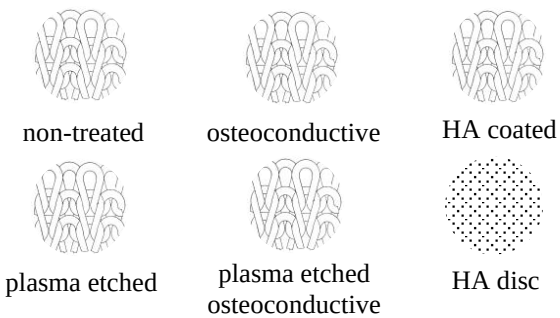


Figure 2: Left: schematic representation of experimental set-up. Right: Experimental groups.