Spreading performance in 3D printed scaffolds for bone tissue engineering

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Introduction and Aims

The potential to grow cells in vitro could drastically expand the horizons of regenerative medicine, as more tissues and potentially organs would be available. The aim of this study is to first produce a porous scaffold with precise pore morphologies via computer aided design (CAD) and 3D printing technology; and to then subject these scaffolds to spreading tests. As well as this the scaffolds will have parameters such as porosity measured, via using a pycnometer, scanning electronic microscopy (SEM) image processing and calculations based on the design parameters. Permeability is The uniform regularity of the scaffolds produced will accurately allow for pore diameters and scaffold thickness are completed with image J. The uniformity of the scaffolds produced will accurately allow the effects of scaffold porosity to be investigated and see how it affects interactions with cell culture medium.

Materials and Methods

1. CAD scaffold design

Various scaffolds were designed using the software Siemens NX® (Siemens, UK). First, the scaffold was specified in the programme, with dimensions of 10 mm x 10 mm and thicknesses between 0.5 mm – 2 mm. The pattern feature is shown in table 1.

Table 1 the physical properties of the produced porous scaffolds 3D printing

<table>
<thead>
<tr>
<th>Scaffolds No.</th>
<th>Pore shape</th>
<th>Pore diameter/length (mm)</th>
<th>Distance between pores (mm)</th>
<th>Scaffolds thickness (mm)</th>
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</thead>
<tbody>
<tr>
<td>S1</td>
<td>Circle</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>S2</td>
<td>Circle</td>
<td>0.50</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S3</td>
<td>Circle</td>
<td>0.50</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S4</td>
<td>Circle</td>
<td>1.00</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S5</td>
<td>Circle</td>
<td>1.00</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>S6</td>
<td>Circle</td>
<td>0.50</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>S7</td>
<td>Circle</td>
<td>0.50</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S8</td>
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<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S9</td>
<td>Square</td>
<td>0.39</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>S10</td>
<td>Square</td>
<td>0.78</td>
<td>0.50</td>
<td>1.00</td>
</tr>
</tbody>
</table>

2. Porosity measurements

The porosity are measured using a pycnometer method, image processing and calculation based on design parameters. Pycnometer method is based on equation 1.

$$ \varepsilon = \frac{m_1 - m_2}{\rho w}$$  \hspace{1cm} (1)

- $m_1$ - the mass of the water solution
- $m_2$ - the mass of the porous scaffold
- $\rho w$ - the density of water

Image processing was done by uploading SEM images to the prepared MATLAB® file® to calculate what areas of the scaffold were porous or not. The porosity of the scaffolds was also calculated from the design specifications based on equation 2.

$$ \varepsilon = \frac{V_p}{V_t} = \frac{V_t - V_w}{V_t}$$  \hspace{1cm} (2)

- $V_p$ - the volume of the designed scaffold with completely unblocked pores all with equal, constant diameters
- $V_t$ - the total volume of the scaffold block without any pores.

4. Spreading experiments

KRUSS DSA100 drop shape analyzer is used to monitor the water (as reference) and CCM spreading process on the 3D printed scaffolds surface. 10ul water /CCM drop is placed on the scaffold surface by pipette. The time evolution of volume of CCM and water droplets were recorded and calculated using the recorded images. The camera would record as the CCM or water droplet touched the scaffold and finished recording after the spreading had completed, or after a period of 30 minutes.

Reference: